APRIL, 1961
Vol. 15, No. 4

FT food technology

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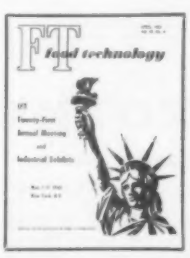

APRIL COVER. The familiar Statue of Liberty has been chosen by the host New York Section as its symbol of invitation to the food industry, to attend the 21st Annual Meeting and Industrial Exhibit of the Institute of Food Technologists. You are invited to be present May 7–11 at the Statler Hilton Hotel and participate in this meeting, which will feature the latest scientific developments in the food field. One hundred twenty exhibitors will occupy 143 booths, and display the latest in products, processes and equipment. For specific information, see the Program Insert and page 28 of this issue.

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A New Method for Heat-Processing Canned Foods

M. Beauvais, G. Thomas, and H. Cheftel

Research Laboratories, Ets. J. J. Carnaud and Forges de Basse-Indre, Paris, France

SUMMARY

Rotation at 120 rpm and carrying the cans through gas flames are the features of a new continuous sterilizer that enables high-temperature short-time processing of mobile products such as peas in brine. The cans, pushed by transverse bars along a flattened spiral runway, are first pre-heated in steam, then brought up to processing temperature, held at such temperature, and finally cooled by water sprays. The temperature of the cans is measured with a wire thermocouple over which they pass, and checked with the help of organic compounds of definite melting point sprinkled on the cans. Advantages (short coming-up time, quick process, no inlet or outlet valves, easy accessibility of all parts) and disadvantages (no external counter-pressure on the cans) are discussed.

RESEARCH on heat-processing milk in tin-plate cans (Cheftel and Thomas, 1958) that resulted in a hot-air sterilizer now used commercially in canning milk (Cheftel and Beauvais, 1957) led us to observe that rapid heating of the contents, either liquid or mobile, of a can in a heating fluid requires that the heating fluid be brought to the highest practical temperature and the can agitated energetically.

Since the rate of heat penetration is at every instant proportional to the difference between the temperatures of the heating fluid and of the can, this difference should always be large; in this case, the heating of the can follows the first portion of the logarithmic heating curve, with the double result that: 1) the heating is very rapid, and 2) it takes place along the section of the curve that can be taken as a straight line (Fig. 1). (One of the authors, G. Thomas, has taken advantage of this fact in developing a new method of process calculation.)

Agitating the can increases the rate of heat transfer from can to contents, thereby maintaining a lower temperature in the walls of the can, which otherwise would rapidly equal the temperature of the heating fluid.

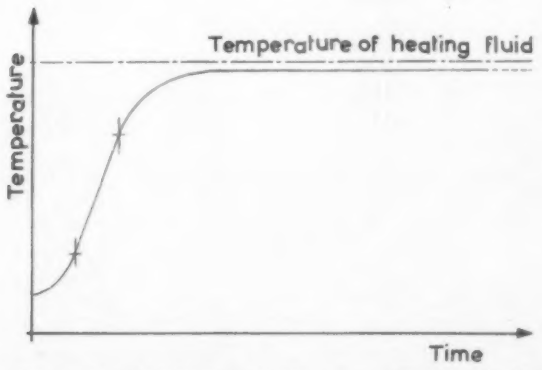


Fig. 1. Classical heat-penetration curve. The two vertical lines show the section of the curve along which we work.

Agitation in most commercial sterilizers is not efficient enough for adequate heat penetration. Further, these sterilizers use either water or steam as heating fluid, each almost motionless at temperatures below 130°C (266°F); the result is that, even with efficient agitation of the can, as, for instance, in the retort designed by Clifcorn (1950), indaequate heat reduces process efficiency. The two devices used by Ekelund (1954) in his hot-air sterilizer are, in fact, a higher temperature, and a high speed of circulation of the heating fluid; he neglected, however, to impose sufficient agitation on the cans, and also was probably hampered by the problem of resistance of the can ends to the pressure developed in the can.

In the hot-air sterilizer we have designed, mentioned at the beginning of this paper, we endeavored to bring together all conditions favorable to rapid heat penetration: air at 250°C (482°F) circulating at high speed; positive and energetic agitation of the cans (rotation at 120 rpm), imparting to cans and contents an almost homogeneous temperature throughout while avoiding scorching the product. Precise measurements have shown that the center of the rotating can and the can walls have practically identical temperatures when the product is sufficiently mobile.

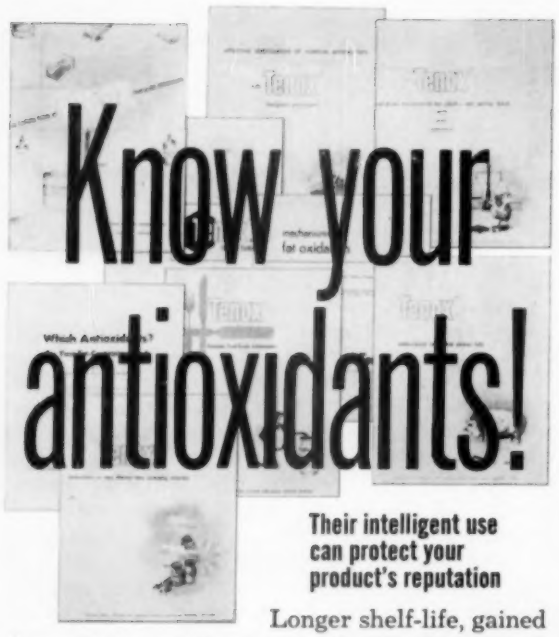
These observations prompted us to look for a still more efficient method of heating.

Increasing air temperature and speed of circulation might offer a solution; we have, however, discarded this as impractical and too costly.

Infrared radiation, which is used commercially in drying paint on automobile bodies, seemed attractive on account of its simplicity; infrared radiation is, however, said to have little penetrating power, and we had to deal with the brilliant surface of tin-plate cans. Consider, however, the Stefan-Boltzman equation:

$$k = fA\left(\frac{T^4 - t^4}{273}\right)$$

in which k is the transmission coefficient, T the absolute temperature of the emitting surface, t the temperature of the exposed surface, f a constant, and A the area of the emitter. It may be seen that k is proportional to the 4th power of the temperature of the emitting source. Thus, a source at high temperature should offer radiation of great penetrating power. The point was confirmed by experimentation with special burners with emitting surfaces at 1350°C (~2450°F). (The burners were made by the Société



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pour la Construction d'Appareils Thermiques, 29 rue Mogador, Paris 9e, whose cooperation we acknowledge.) The radiations thus produced easily pass through surfaces exposed to them, even brilliant ones, and by this means we have achieved very rapid heating of liquid or mobile products sealed in tin-plate cans or even in glass bottles of usual commercial type (Cheftel and Beauvais, 1958).

Interest in high-temperature short-time sterilization needs no demonstration, since many studies carried out in the United States have culminated in the processes of aseptic canning. These developments have been reviewed by Ball (1951).

Experiments we have carried out on fresh peas, green beans, and carrots have given very encouraging results, in regard to both color of product and other characters.

Since thermal radiation, even from a source at high temperature, is strongly absorbed by air, the emitting burners were placed only a few millimeters from the surface of the cans. Even so, lithographed cans withstood the treatment when kept in constant rotation. This observation induced us to heat the cans by direct contact of a gas flame (blue flame at a Méker burner). The very simple setup used is shown in Fig. 2.

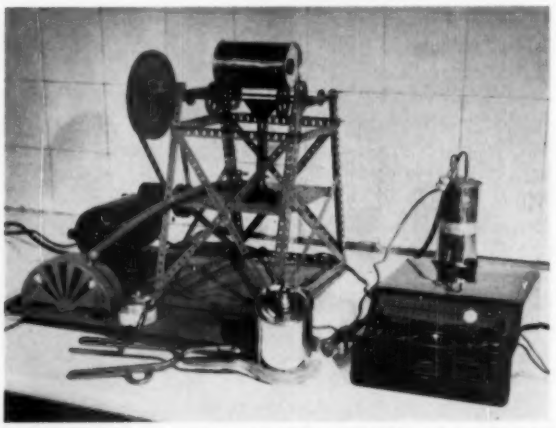

Fig. 2. Device for flame-heating a rotating can. On the bottom of the latter may be seen the head of an Ecklund thermocouple; on the right of the picture, a potentiometer and the cold junction.

The results were as satisfactory as in the previous case. Thus, it seemed advisable to abandon infrared emitters in favor of flames, a much less expensive source of heat.

Results obtained with the apparatus of Fig. 2 establish that the temperature of a 71.5×115.5 mm ($\sim 213 \times 409$) can of peas can be raised from 98 to 125°C ($\sim$208 to 257°F) in 45 seconds. The rate of heat penetration depends not only on the dimensions of the can and the physical characteristics of the product but also on the conditions of heating. Simple and rapid regulation of the flames allows greatest flexibility in this respect.

Our preliminary experiments were helped by an-

other observation. At first, the temperature of the contents of the can was measured by Ecklund (1949) thermocouples fixed into the rotating can and attached to a connector with which copper and constantan wires leading to the potentiometer were in sliding contact. Such a device is relatively complicated, and cannot be used for cans moving on a conveyor. We noticed, however, that in our operating conditions, thermal equilibrium between can and contents is attained almost instantaneously as soon as the flame is removed. We therefore assumed that measuring the temperature of the can surface would probably be sufficient, and this was confirmed experimentally.

We have used two methods of measuring the surface temperature of the can:

1) The can was used as a kind of Maquenne's block for melting-point determinations, i.e., a few minute crystals of some organic compound of well-defined melting point were deposited on its surface, and their behavior observed. Using compounds whose melting points differ from one another by not over 1°C (~2°F) makes it possible to encompass quite closely the processing temperature that is to be checked. It will be appreciated that this method of temperature measurement is fool-proof, and may be used to check other instruments.

2) The can rolled over a ribbon thermocouple 15 mm long, 5 mm wide, and 0.2 mm thick. Special precautions were taken to reduce the inertia of the instrument and to increase its accuracy; a complete description will appear elsewhere, since it may have wider applications.

Each of the continuous sterilizers to be described herein is provided with such a thermocouple and with a device permitting removal of a can at will to check temperature by the melting-point method.

How could direct heating by flames be applied to a thick product? Heat penetration in pureed vegetables, for example, in contact with a flame is not influenced by agitation. The heat is transmitted too slowly by conduction toward the center of the can, and the external layers of the product become overheated more or less rapidly, according to the product, and undergo a quick decomposition accompanied by abundant evolution of gases. The can swells and finally bursts.

Even so, direct flame heating becomes possible if interrupted at regular intervals, allowing the heat to diffuse into the product. Through application of what we term "alternating thermal impulses," flame heating may thus be applied to even relatively thick products. True, heat penetration is certainly far slower than with mobile or liquid products, but the other advantages of direct flame heating (simplicity, low cost, reduced dimensions) are preserved.

The sterilizing process, then, consists essentially in bringing up rapidly, by single or repeated heat impulses, can and contents to about 125°C (257°F), maintaining this temperature for the time necessary for sterilization, and finally cooling rapidly. A most important point is that the cans must all be at the same temperature when brought into contact with

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flames, because the heating curve is almost a straight line; thus, every difference in initial temperature gives a corresponding difference in final temperature. Proper control of the process requires ±0.5°C (±1.5°F).

Practical application of this method was confronted with numerous problems.

One of these, the resistance of cans to internal pressure without counterbalancing by outside pressure, had already been encountered with the hot-air sterilizer. Small-diameter cans (55 mm; 203) raise no difficulty; they resist very well. For larger cans (71.5 or 73 mm diameter; 213 or 214) it is sufficient to choose the proper temper and thickness of the plate and profile of the ends, and to close the cans at a temperature of at least 80°C (176°F). Such precautions do not quite suffice for cans of still-larger diameter; for such a case a number of possibilities are being considered, including the use of ends similar to those of the beer can.

Sterilization could, of course, be carried out at 115 or 120°C (239 or 248°F) instead of at 125 or 130°C (257 or 266°F); heat penetration would still be rapid but many advantages of a high-short process would be lost.

Designing and building a machine for the process introduced more problems. Come-up, holding, and cooling times had been established experimentally on cans inoculated with heat-resistant spores (about 10,000,000 spores of *Clostridium sporogenes* PA 3679), and, starting from these data, we had to design an apparatus that would give exactly the same thermal treatment to each can; to place the burners so as not to expose the conveying system to excessive heat; and to provide for the discharge of the combustion gases. It was also necessary to pre-heat the cans to exactly the same temperature before putting them in contact with the flames. All this for an output of 200 cans per minute, with all necessary control and safety instruments.

We chose butane or propane as fuel (natural gas will do too); those gases have the advantage of burning with very hot and clean flames. In regard to the burners, we adopted those (Fig. 3) developed by the Société pour l'Utilisation Rationnelle des Gaz (1950, 1953). (We thank the Société U. R. G., and particularly Messrs. Liautier and Charié, for help and advice.)

Device for steadying the flames (detail).

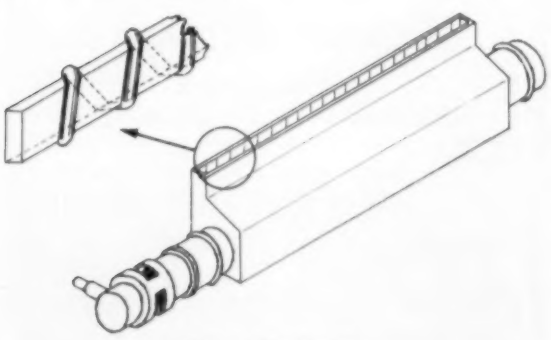

Fig. 3. Gas burner.

To ensure that each can would receive the same treatment, we adopted the principle of moving them on the same track. A spiral cylindrical run, as used in many continuous cookers and coolers, has a number of disadvantages with flame heating. A straight-line conveyor, for the proposed output, would be unacceptably long. The solution of this problem, given by J. Arnoux, design engineer in the Technical Development Department of Etablissements Carnaud-Basse-Indre, was patented separately (Ets. J. J. Carnaud, 1959).

It consists in moving the cans along a flattened spiral made of two rows, one above the other, of straight horizontal runways slightly askew relative to the longitudinal axis of the machine, linked at the ends by semi-circular runways set in vertical planes parallel to the axis of the machine (Fig. 4-A). The

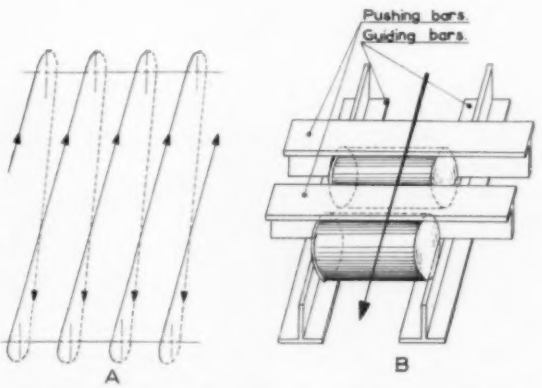

Fig. 4. Sketch of can run (A), and system for driving the cans along the track (B).

cans are pushed along this path by transverse bars fixed to two endless chains; thus, the cans rotate while they move on the runways of the lower row (Fig. 4-B), but do not during transfer along the runways of the upper row when they rest upon the pushing bars. A variable-speed drive permits changing the speed of the cans without stopping the machine. The burners are a number of independent elements, thereby providing great flexibility for controlling heat according to can size and product. The combustion gases leave the heater at about 500°C (932°F). A small portion of this heat is presently used for maintaining the appropriate temperature in the holding section; a more complete recovery is planned.

The complete sterilizer is made up of four sections: in the first, the cans are surrounded by free steam, and their temperature is uniformly brought up to the temperature of the steam; in the second, the cans pass through the flames and are brought to the sterilizing temperature; in the third, where heat is supplied by

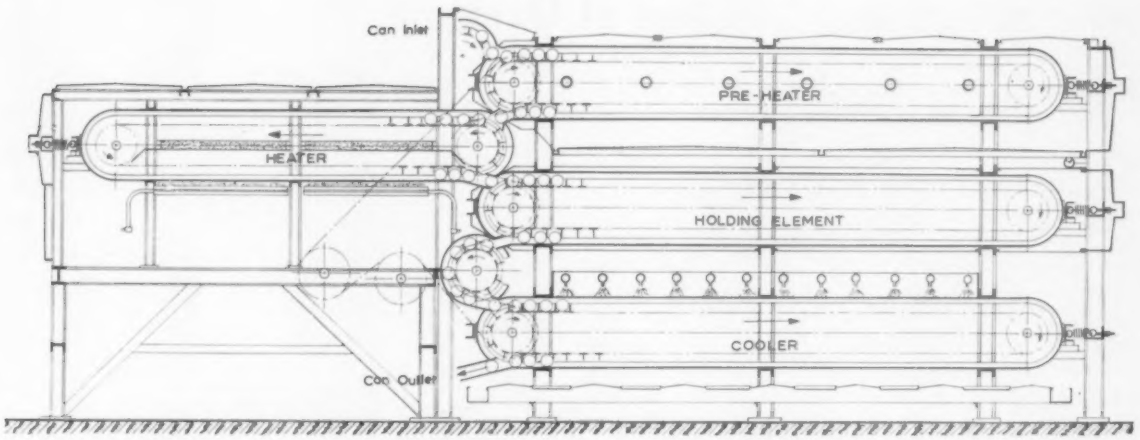

Fig. 5. Longitudinal section of the flame-sterilizer.

part of the combustion gases, they are held at sterilizing temperature; in the fourth, they are cooled under fine water sprays (Fig. 5, 6).

The first sterilizer, with an output of 180 71.5 × 115.5 mm (213 × 409) cans per minute, was used in the 1959 pea canning season; three more, set up in other canneries, operated satisfactorily during the 1960 pea season. We gratefully acknowledge the part that A. Jeanneau, manager, and A. Martin, design engineer, of the Technical Development Department of Etablissements Carnaud-Basse-Indre, played in solving the many mechanical problems we had to cope with.

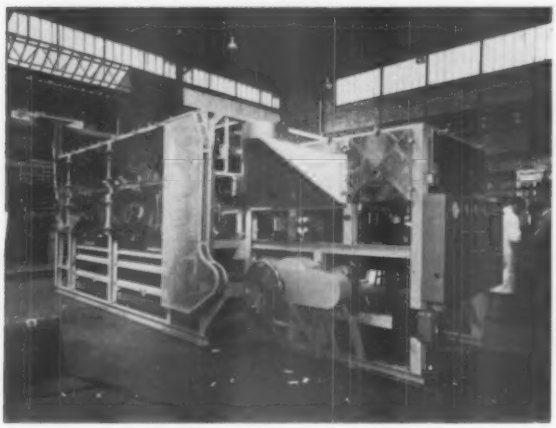

Fig. 6. The flame-sterilizer.

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Development and Inhibition of Oxidative Rancidity in Foods[a, b]

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MAN HAS BEEN PLAGUED by food spoilage since his beginnings. From our knowledge of surviving primitive societies, it is not difficult to imagine the ancestor of modern civilized man partaking of food where he could find it and in almost any state. As man passed from the food gathering stage to the food growing stage, he became increasingly conscious of the desirability of having food fresh or preserved in a palatable state.

The history of man is filled with evidence of efforts to preserve food by many methods. As a result of these preservation methods, many of our foods are now preferred in the state which resulted from development of these means of preservation.

Among the numerous types of spoilage and deterioration of food, oxidative spoilage has always been an important factor. This can occur in many ways but is most commonly recognized as oxidative rancidity, which is characterized by typical objectionable odors and flavors, deterioration of nutritional value, and changing physical properties.

Mechanisms of Oxidative Rancidity

Oxidative rancidity in foods has been traced to the lipid portions, in which both the simple triglycerides and the more complex phospholipids and lipoproteins may be involved. The common feature of oxidative rancidity is the reactivity of the unsaturated fatty acid moieties in the lipids. In a refined fat or oil the oxidation usually proceeds through autocatalytic processes, but in foods the systems and the processes become more complex. These complex systems bring into play the effects of moisture, salts, proteins, carbohydrates, enzymes, and pigments. Some of these factors exert an important effect on the rate and course of oxidative reactions. Because the rate and course may vary, it is logical to expect that differences in the mechanism result from the various influencing factors.

The generally recognized oxidative mechanisms involve autoxidation, lipoxidase-catalyzed oxidation, and hematin-catalyzed oxidation. These mechanisms show differences in initiation processes, activation energies, and rates of oxidation. Since linoleic acid is a constituent of so many food lipids and is readily oxidized, its esters and compounds are frequently used in model systems to elucidate the factors that characterize the differences in oxidative mechanisms.

Autoxidation occurs in a series of reactions involving initiation, propagation, and termination steps. These can be formulated as:

Initiation

$$RH + O_2 \longrightarrow R^{\cdot} + {}^{\cdot}OH \quad [1]$$

Propagation

$$R^{\cdot} + O_2 \longrightarrow ROO^{\cdot} \quad [2]$$

$$ROO^{\cdot} + RH \longrightarrow ROOH + R^{\cdot} \quad [3]$$

Termination

$$R^{\cdot} + R^{\cdot} \longrightarrow RR \quad [4]$$

$$R^{\cdot} + ROO^{\cdot} \longrightarrow ROOR \quad [5]$$

$$ROO^{\cdot} + ROO^{\cdot} \longrightarrow ROOR + O_2 \quad [6]$$

RH refers to any unsaturated fatty acid in which the H is labile by reason of being on a carbon atom adjacent to a double bond. $R^{\cdot}$ refers to a free radical formed by removal of a labile hydrogen.

The initiation process should have an activation energy of about 45 Kcal/mole. The propagating steps have lower activation energies. Oxidation of the linoleate system is characterized by conjugation of the double bonds to form conjugated diene hydroperoxides. These hydroperoxides permit evaluation of oxidation both by peroxide determinations and spectrophotometric measurements.

The over-all oxidation may be expressed as $RH + O_2 \longrightarrow ROOH$ up to a certain stage of oxidation. The oxidation process becomes more complex after the development of a quantity of ROOH, for the ROOH then decomposes, either through thermal instability or through reaction with other materials, to form more free radicals, which then participate further in the chain reactions. Bateman *et al.* (1953) showed that this decomposition can be both monomolecular and bimolecular. The monomolecular hydroperoxide decomposition may be illustrated by $ROOH \longrightarrow RO^{\cdot} + {}^{\cdot}OH$. The bimolecular decomposition may be illustrated by $2\ ROOH \longrightarrow ROO^{\cdot} + RO^{\cdot} + H_2O$. Bateman also found evidence of an equilibrium between a hydroperoxide dimer and two moles of a hydroperoxide monomer. At low concentrations of hydroperoxide and at higher temperatures the decomposition would be mainly monomolecular since these conditions favor dissociation of the dimers.

It has been difficult to establish systems suitable for demonstrating both stages of oxidation. Recently, however, Jensen and Dugan (in preparation) and Mabrouk and Dugan (1960), working with aqueous suspensions of linoleic acid or methyl linoleate, demonstrated the existence of both stages of oxidation and have calculated the activation energies for each stage. The respective activation energies were 19.6 Kcal/mole and 16.4 Kcal/mole for the stage governed by monomolecular decomposition and the bimolecular decom-

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[b] Presented at 20th Annual Meeting of the Institute of Food Technologists, May 15–19, 1960, San Francisco, California.

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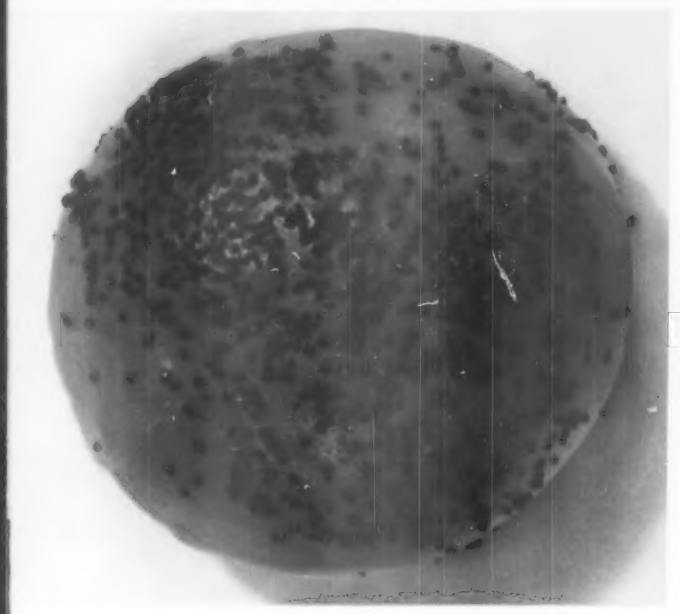

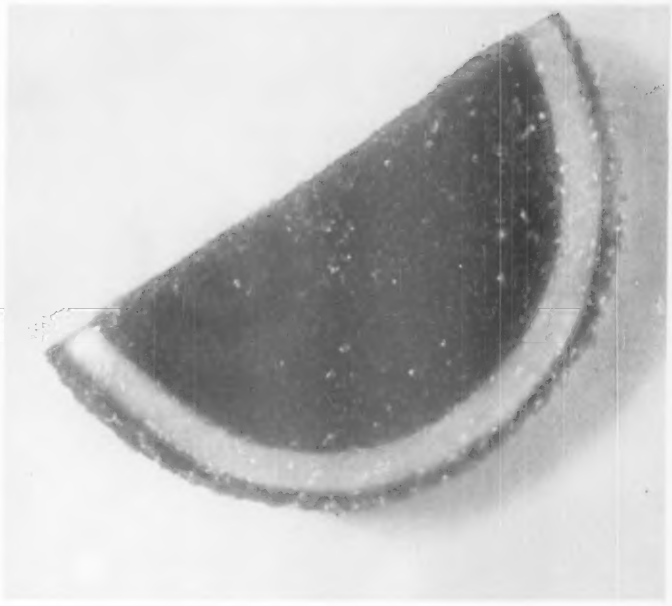

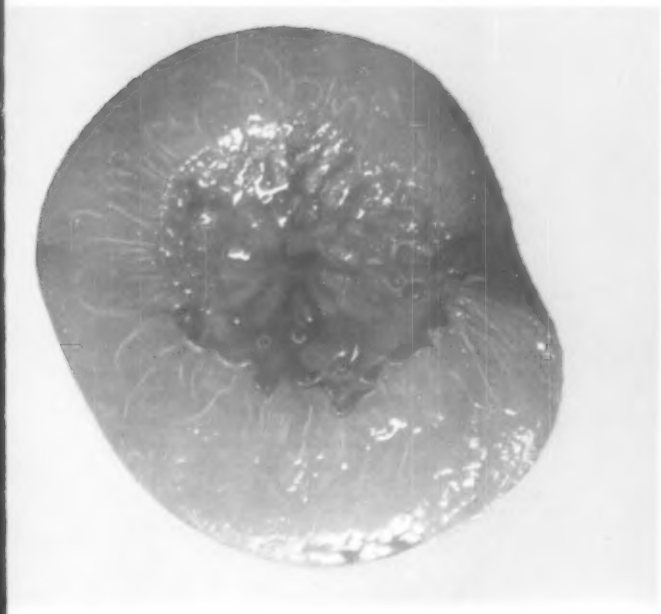

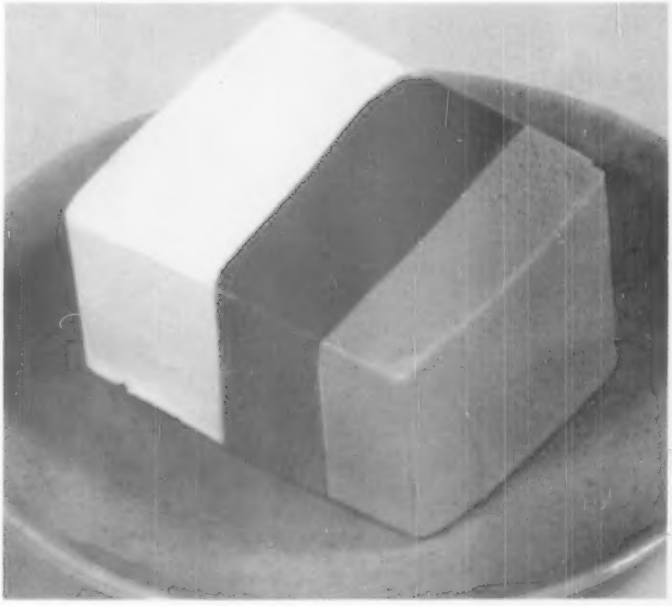

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The enzyme lipoxidase, found in many plant products, is capable of catalyzing the oxidation of unsaturated lipids. Numerous studies have shown that these oxidations can proceed at low temperatures and that the primary products of the oxidation are diene-conjugated hydroperoxides with a molecular extinction coefficient greater than is found in similar products from autoxidation. Berkstrom and Holman (1948) postulated that lipoxidase could cause initiation of a free-radical chain reaction similar to that occurring in the autoxidation of a linoleate system. Because of rate and spectral characteristics, Lundberg (1948) proposed that lipoxidase may form a complex with each linoleate molecule and thus influence the structure of the resulting peroxides. Tappel *et al.* (1952) elaborated on this concept by proposing a mechanism involving formation of a linoleate, oxygen, lipoxidase complex. This is followed by transfer of an electron and hydrogen ion from linoleate to oxygen to form a bi-radical, which then reacts to form a conjugated peroxide while still under the directive influence of the enzyme, and finally the peroxide dissociates from the enzyme. This may be illustrated simply:

$$RH^{\cdot}\ \text{lipoxidase} + O_2 \longrightarrow \frac{RH + O_2}{\text{lipoxidase}}$$

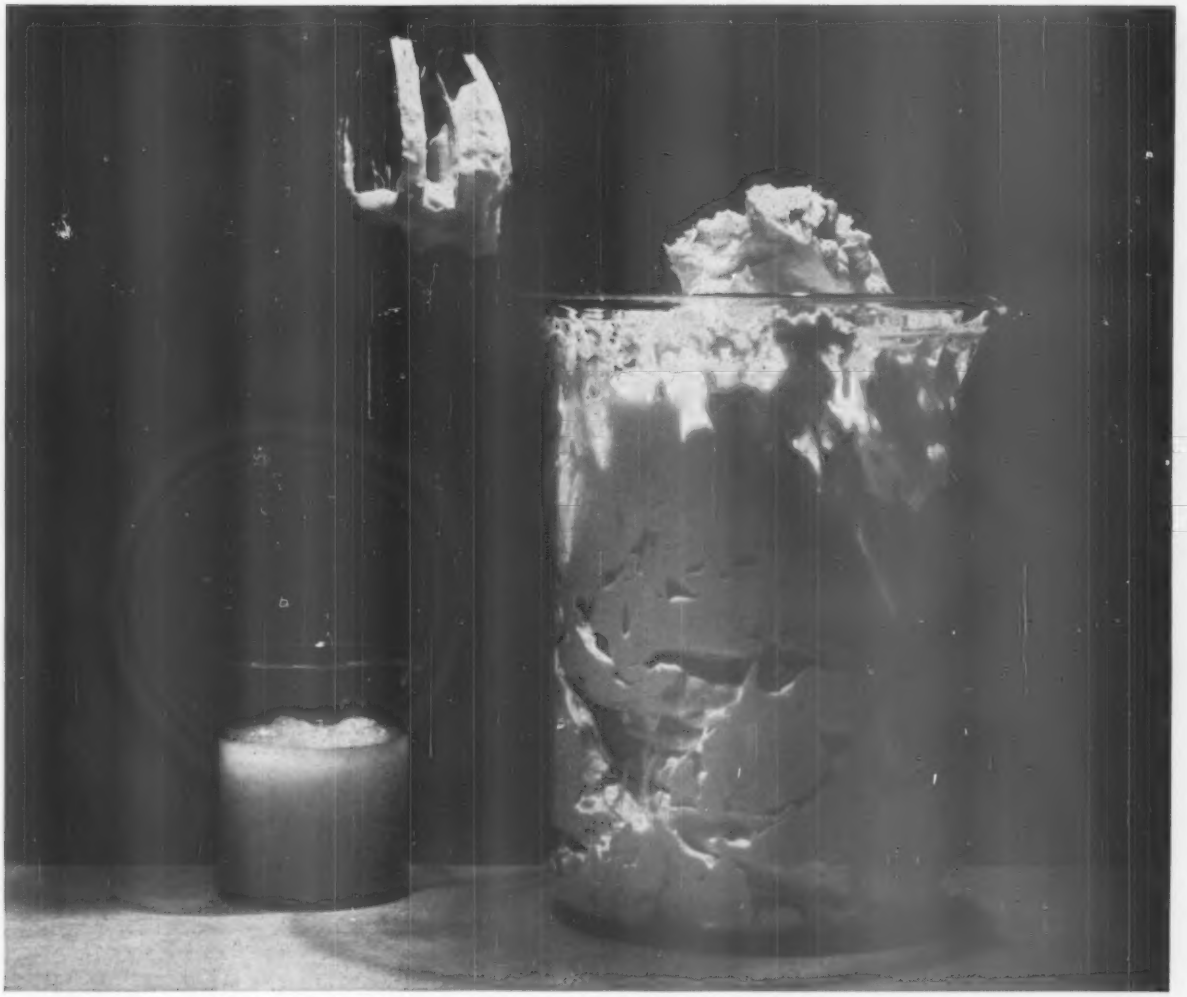
$$\frac{RH + O_2}{\text{lipoxidase}} \longrightarrow \frac{R^{\cdot} + {}^{\cdot}OOH}{\text{lipoxidase}}$$

$$\frac{R^{\cdot} + {}^{\cdot}OOH}{\text{lipoxidase}} \longrightarrow \frac{ROOH}{\text{lipoxidase}}$$

$$\frac{ROOH}{\text{lipoxidase}} \longrightarrow ROOH + \text{lipoxidase}$$

A feature of importance in lipoxidase-catalyzed oxidation is the low activation energy of 4.3 Kcal/mole reported by Tappel *et al.* (1953). This permits oxidation to proceed readily at low temperatures; and only complete freezing to a solid system, which limits diffusion rates, will bring about a sharp reduction in rate of reaction. On the other hand, phenolic antioxidants such as hydroquinone, propyl gallate, nordihydroguaiaretic acid, and α-tocopherol inhibited the reaction to varying degrees.

The ready development of rancidity in animal tissues during frozen storage indicated the presence of substances that promoted the oxidation of lipid constituents. It was suggested by Watts and Peng (1947) that heme compounds were responsible for the oxidation that takes place in animal tissues. Tappel (1953a) developed a method for determining lipoxidase in the presence of heme compounds. He showed that lipoxidase was absent in the tissues of a number of animals, which supported the concept of Watts and Peng. Tappel (1953b) then studied the hemin cataly-



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sis of the oxidation of unsaturated fatty acids and proposed a mechanism for this catalysis. He postulated that hematin catalysis proceeds through initiation of a chain reaction by two free-radical scission products of linoleate hydroperoxide that result from interaction of peroxide with the iron of the hematin group. The resulting chain reaction then propagates in essentially the same manner as in an autoxidation. This may be represented:

Initiation

$$ROOH + \text{hematin} \longrightarrow ROOH - \text{hematin} \quad [1]$$

$$ROOH - \text{hematin} + 2\,RH \longrightarrow 2\,R^{\cdot} + \text{hematin} + \text{carbonyl compounds} + ? \quad [2]$$

Propagation

$$R^{\cdot} + O_2 \longrightarrow ROO^{\cdot} \quad [3]$$

$$ROO^{\cdot} + RH \longrightarrow ROOH + R^{\cdot} \quad [4]$$

Termination

As in other mechanisms [5]

Tappel determined the activation energy for hematin catalysis, and found it to be only 3.3 Kcal/mole for oxidations catalyzed by hemoglobin or cytochrome C. This low activation energy explains why rancidity of meat products can proceed readily at the temperature of frozen storage.

Younathan and Watts (1959) proposed that the ferric hemochromogen is the active catalyst for unsaturated fat oxidation, and that ferrous nitric oxide hemochromogen is not. More recently, Tarladgis and Watts (personal communication) proposed a mechanism for heme catalysis of oxidation based on the concept that initiation is caused by the iron in the ferric state in hematin compounds. They found no induction period in the oxidation of linoleic acid catalyzed by methemoglobin, but a marked induction period resulted when oxyhemoglobin was used. After the induction period with oxyhemoglobin, the oxidation proceeded at a rate comparable to that when methemoglobin was used. They postulated that since the iron in methemoglobin is paramagnetic, it thus would have an accelerating effect on reactions favoring the formation of free radicals. Methemoglobin is also electron-deficient, and therefore can act as an electron acceptor. The radicals induced in an unsaturated system by methemoglobin then participate in a chain reaction mechanism that results in the accumulation of peroxides. If an electron were to be transferred from the abstracted hydrogen or other source to the methemoglobin, the iron would be reduced to the ferrous state and then could act as a peroxide decomposer to provide more radicals, further accelerating the oxidation. This mechanism, based on the electronic configuration and valency state of the iron in hematin compounds, provides an explanation of the oxidative changes in cooked, frozen, irradiated, and cured meats.

Oxidation is affected by light, temperature, pro-oxidant metals, and salt. The effects of elevated temperature and light are readily explained. The role of pro-oxidant metals can be explained in the framework of the explanations for hematin catalysis. Salt presents a problem that has not been satisfactorily resolved. The accelerating effect of salt on rancidity in meats has been reviewed by Watts (1954). It was pointed out that salt accelerates rancidity only when it is brought into contact with fat over a wide surface and that dilute salt solutions brought into contact with unsaturated fat may actually retard oxidation. Salt also accelerates the oxidation of hematin compounds to the ferric state, whether or not fat is present. It may be speculated that the role of salt, then, may be to accelerate formation of the ferric state, which in turn initiates oxidation of the adjacent unsaturated lipid components as described above.

Controlling Oxidative Deterioration

Many foods and materials can be kept free of oxidative deterioration for long periods by physical or chemical means or a combination of these means. Foremost, of course, is careful and rapid processing to preserve natural stability and antioxidants. Heating is important to the preservation of systems containing pro-oxidant enzymes that may be inactivated, or of some systems that develop antioxidant-active materials through thermally induced reactions. Eliminating or minimizing metal contamination and/or light protects some materials. Vacuum packaging or packaging in an oxygen-free atmosphere protects many foods. Oxygen scavengers are sometimes used for this purpose. Low-temperature storage protects against or reduces the rate of oxidation. The temperature required to be effective varies widely with the nature of the system and with the presence or absence of pro-oxidant catalysts. Hydrogenation of unsaturated lipid materials markedly improves their resistance to oxidation. Many foods may have their natural stability improved by smoking or by adding edible stabilizing materials, such as spices, sugar, citric acid, and cereal flours. Many fats, fatty foods, and foods processed in fats or oils are regularly stabilized by adding approved antioxidants.

Functioning of Antioxidants

Antioxidants may generally be considered to function in two ways, either as inhibitors or as peroxide decomposers. The peroxide decomposers act as catalysts to decompose peroxides initially present as well as those that are formed during further oxidation. An important feature of this decomposition process is that the primary stable products are not free radicals. This naturally rules out the use of metals for the decomposition of peroxides since they provide more radicals for participation in the chain-reaction mechanism. Peroxide decomposers become relatively more effective than free radical inhibitors at high concentrations, and relatively less effective at low concentrations. For this reason, this type of antioxidant is not used in the food field since one of the criteria for a food additive is that it should be effective in low concentrations.

Antioxidants that function as free radical inhibitors react with the chain-carrying free radicals to form inert products as a termination step in the chain-reaction mechanism. Peroxy radicals probably pre-

dominate in this termination step since hydrocarbon free radicals react very readily with molecular oxygen. The mechanisms of antioxidant functions have been reviewed (Dugan, 1957).

Synergists and Synergism

Certain acidic compounds have been recognized for many years as materials that in themselves provide no apparent protection against oxidative spoilage. These materials provide an enhanced effect when used in conjunction with phenolic antioxidants, and thus are known as acid synergists. When the role of metals such as iron and copper as catalysts for fat oxidation was established, it was noted that the acid synergists were primarily materials that inactivated metals by chelation. Most frequently used have been citric acid and its esters. Citric acid was more effective against iron and nickel than against copper, and ascorbic acid was effective against copper but ineffective against iron (Morris *et al.*, 1950). Amino acids (Lundberg, 1950) and sulfur compounds (Schwab *et al.*, 1953) have been shown to possess synergistic, and sometimes apparent antioxidant, effects in various lipid systems.

Although acid synergists may be effective primarily because of their metal-scavenging properties, there are other examples of synergism that cannot be associated with this effect. It is well known that phenolic antioxidants influence the behavior of one another when more than one are used in the same system. It has been shown that a positive synergistic effect results from joint use of BHA (butylated hydroxyanisole; a mixture of the 2-*t*-butyl and 3-*t*-butyl-4-methoxyphenols) and propyl gallate in lard (Kraybill *et al.*, 1949), and that propyl gallate has a protective effect on BHA during aging in a fat (Mahon and Chapman, 1953). The isomers of BHA are synergistic with each other, as is the combination of BHA and BHT (butylated hydroxytoluene; 2,6-di-*t*-butyl-4-methylphenol) in lard (Dugan *et al.*, 1954). The synergistic effect produced in fat, either by interaction of two phenolic antioxidants or by an acid synergist with a phenolic antioxidant, is seldom observed in carry-through. This is probably due to antioxidant distillation and/or destruction during cooking.

The term synergism may thus be applied to several modes of interaction of antioxidant and other materials so as to enhance the stability provided by antioxidants. These may be metal scavening, peroxide decomposing, or mutual sparing effects, as in the case of the interaction of phenolic antioxidants.

Antioxidants in Foods

The antioxidants approved and widely used in fats and foods are the phenolic type. The gallate esters are widely used, and propyl gallate is frequently used in antioxidant combinations. BHA has been found to be

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especially valuable in the stabilization of fatty foods that require heat processing (Dugan *et al.*, 1950, 1951; Kraybill *et al.*, 1949).

Nordihydroguaiaretic acid has been found effective in many applications, both alone and in antioxidant combinations. BHT is another approved antioxidant that can be used in heat-processed foods. Many commercially available antioxidant formulations contain BHT and BHA, or BHT with propyl gallate or nordihydroguaiaretic acid and citric acid. The hindered phenolic antioxidants BHA and BHT provide the "carry-through" stability so necessary in heat processing; the gallates or nordihydroguaiaretic acid provides stability for fat stored until use in heat processing of foods; and citric acid acts primarily as a scavenger of pro-oxidant metallic contaminants.

The tocopherols, which occur naturally in plant products, are variable in their effect as antioxidants. The antioxidant activity sometimes appears to act inversely with the vitamin E activity of the tocopherols, since alpha-tocopherol may be the least effective antioxidant and delta-tocopherol is quite effective as an antioxidant but very poor in vitamin E activity.

Lea (1960) recently emphasized that antioxidant behavior varies with the fatty acid composition of the substrate, and with the temperature and level of oxidation at which the measurements are made.

Applications of Antioxidants

Antioxidants effectively protect the color, flavor, aroma, and nutritive value of an almost countless number of food items. The wide scope of use, and the variety of the applications, have been reviewed (Kraybill and Dugan, 1954).

The scope of application may be illustrated by noting some of the many products stabilized by antioxidants: fats, oils, shortening, essential oils, crackers, cookies, pastry and cake pre-mixes, candies, corn chips, nuts, pepper and other spices, dehydrated soups, frozen meat pies, animal feeds, and packaging materials. New uses and applications appear constantly.

Irradiation and Oxidation

When unsaturated fatty acids or their esters are exposed to ionizing radiations in the presence of oxygen, chain reactions are induced that are similar to autoxidation except for initiation (Dugan and Landis, 1956; Mead, 1952). When Polister and Mead (1954) irradiated methyl linoleate emulsions containing certain vitamins and antioxidants, vitamin A and ascorbic acid were largely destroyed but gamma-tocopherol and 2,6-di-tert-butylphenol effectively inhibited irradiation-induced oxidation. Chipault *et al.* (1957) found that irradiating fats with high-energy ionizing radiations in the presence of oxygen produced appreciable amounts of peroxides and carbonyl compounds. They also noted flavor and other changes that did not correlate well with either peroxide values or carbonyl compounds. They suggested that high dose rates produced high concentrations of free radicals, which caused relatively short reaction chains. It was further noted that the antioxidant effect of propyl gallate in an irradiated system was less than that found in an autoxidizing system.

Groninger *et al.* (1956) showed irradiating beef and pork in vacuum or inert atmospheres greatly reduced the formation of peroxides and carbonyl compounds. Erdman and Watts (1957) noted that sodium ascorbate and excess nitrite provided color and odor protection during radiation and brief storage periods of cured meats such as ham and bologna. They also found that ground pork, mixed with curing salts, sodium ascorbate, and liquid smoke, irradiated, and then heated to destroy enzymes, retains good color and odor over six months at room temperature. In another study, Tarladgis *et al.* (1959) found that antioxidants improved the odors of irradiated cooked pork. Antioxidants that were effective, alone or in combination with sodium ascorbate, included polyphosphates, green tea extracts, trihydroxybutyrophenone, and tomato soup.

Many foods can now be maintained in a palatable nutritious state for extended periods because of the development of means of preventing or delaying oxidative rancidity. Advances have been marked in processing and storing foods and in developing additives that improve keeping quality. Many of the methods and materials used are based on empirical knowledge because of inadequate understanding of deteriorative processes and the mode of action of the preventive means employed. There is no general rule for the employment of an antioxidant in any system. Antioxidants vary in effectiveness in different systems and under differing conditions of stress. Development of knowledge of the mechanisms of oxidative deterioration and of the role played by the preventive means is providing a basis for ultimate prevention of a major portion of the economic and nutritional waste now produced by oxidative rancidity in foods.

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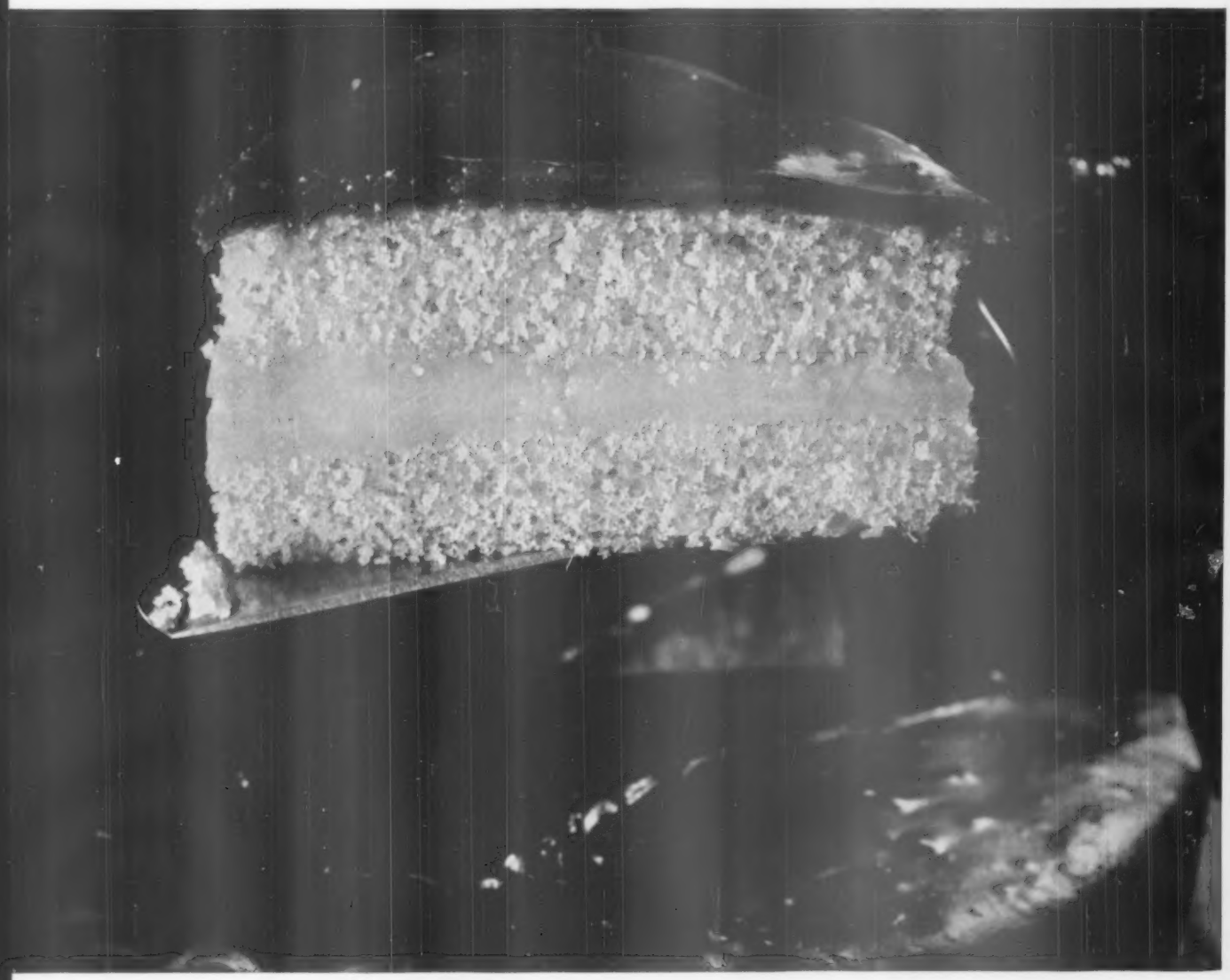

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Book Review

FOOD FLAVORINGS, COMPOSITION, MANUFACTURE, AND USE. Joseph Merory. ix + 381 pages. Avi Publishing Co., Inc., P. O. Box 388, Westport, Conn. 1960. $12.50.

Flavor is of paramount importance to the palatability of all food. The abundant variety of flavoring substances provided in nature does not appear to be

sufficient to serve the rapidly expanding food industry. The requirements for additional flavor chemicals have grown on an enormous scale. The chemical industry has busied itself, in the last half century, in supplementing nature by duplicating many aromatic substances with more powerful odors and tastes than nature produces. In many instances they have succeeded in producing flavor materials in unlimited quantities which are economical to use. As the author states in his introduction, "The literature in regard to food flavorings has been very meager during the last 50 years. Formulas and preparation of food flavorings have been kept under severest secrecy everywhere." This book is an effort by the author to bridge this gap and provide the practicing manufacturing chemist, food manufacturer, and allied workers with a compendium of food flavor formulations. In effect, this book is a manual devoted to the development, manufacture, and use of many kinds of food and beverage flavors, both natural and artificial. The topics run the gamut from fruit and spice flavor through the manufacture of aromatic chemicals, flavor additives, and certified colors. There is also a large section devoted to the use of flavor materials in bakery products, meats, fish, ice cream, liqueurs, and tobacco. Convenient appendices are provided with a brief description of the laws pertaining to certain food additives and the use of paper chromatography for the characterization of vanilla and other plant extracts. The book is profusely illustrated with drawings and photographs of some modern equipment used in the processing and manufacture of flavor extracts. This reviewer believes that *Food Flavorings* is designed to be used by the processor who may not have available to him a large research organization capable of providing food flavor formulations. The book contains very little theoretical discussion about any of the materials and is mostly concerned with the process of how to do, rather than why.

The scientist or other purist may wince at a few sections in the book which depart from conventional scientific nomenclature and accepted usage. For example, many of the formulations in the book contain mixed units of weights and measures. By way of illustration one can cite the reference to imitation coffee flavor on page 172. Here, pounds and grams are used in expressing the formulation. In other places, pounds, grams, ounces, and fluid ounces are all intermingled to express formulations.

There are a number of minor errors in the taxonomic nomenclature descriptive of the plants discussed. One such error appears on page 113 in referring to *Allium cpa* L. (sic!)

The general format of the book is good. The print is clear, paper of excellent quality and the binding appears to be sound. The rather high price of $12.50 may make it prohibitive for students to purchase, but the book will doubtless be of considerable help and value to many food manufacturers who have been looking for a convenient source of food flavor formulas and methods for their manufacture and use.

RICHARD A. BERNHARD

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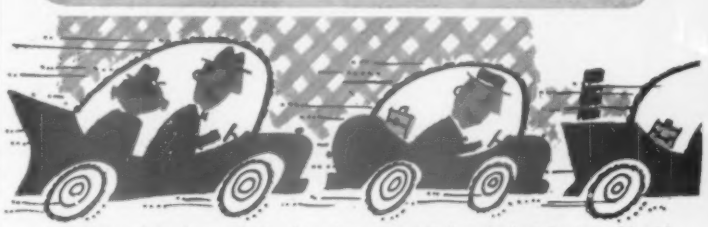
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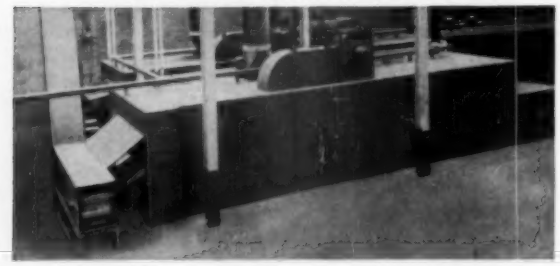

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AGENTS IN PRINCIPAL CITIES
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BIOCHEMISTRY OF PLANTS AND ANIMALS—AN INTRODUCTION. By M. Frank Mallette, Associate Professor, and Paul M. Althouse and Carl O. Clagett, Professors of Agricultural and Biological Chemistry, Pennsylvania State University. John Wiley and Sons, Inc., New York. 1960. XIII + 522 pp.

This book is designed to replace "Introduction to Agricultural Biochemistry," by Dutcher, Jensen, and Althouse (Wiley 1951). One must criticize it in the following aspects:

It is written for the student in general agriculture rather than the student in agricultural chemistry, biochemistry, home economics, or food technology (note Chapters 10 and 16, particularly). Although the authors assume that the student has basic training in organic and inorganic chemistry (viii), their reluctance to use chemical formulae is noticeable. There is inadequate use of figures and diagrams to illustrate the text. Perhaps the most serious criticism is the lack of a quantitative approach to the subject. The authors have failed to give the student an appreciation of how the facts presented were discovered; in other words, an appreciation of research. More references to sources of specific information (not just general references to other text books) could have been included directly in the text without confusing the student. One cannot help but remark on the difference in the quality of the various chapters. It is unfortunate that the authors failed to emphasize, by their subdivisions, the similarity of biochemical reactions in all living cells in an attempt to aid the general understanding of biochemistry.

This book has little to recommend it at a time when there is an oversupply of good biochemistry textbooks already on the market.

JOHN R. WHITAKER

REGIONAL NEWS

FLORIDA

Some food processing companies give bonuses to employees for suggesting new products, services, or cost-cutting procedures, but most companies regard such suggestions as part of their employees' jobs.

That conclusion, from a survey of southern and western Oregon food processing industries, may not represent the industry as a whole. But it should be a useful guide for the future, President-Elect Harold W. Schultz told the Florida Section at a meeting in the San Juan Hotel at Orlando, Florida.

The survey was conducted by the Oregon State College department of food and dairy technology in an effort to learn how best to meet its responsibility to pass new money-making ideas along to industry sources.

Mailed questionnaires were followed by personal visits to selected companies. For the purposes of the survey, ideas were confined to technological changes that would result in: 1) new products or services; 2) lower manufacturing, marketing, or service costs; 3) increased acceptability of products or services.

(Continued on page 25 following Technical Section)

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Acceptability of Repetitive Diets[a, b]

Joseph M. Kamen and David R. Peryam

Quartermaster Food and Container Institute for the Armed Forces, Chicago, Illinois

(Manuscript received August 6, 1960)

SUMMARY

Over-all satisfaction with a three-day self-planned diet was at about the same level as a six-day preplanned (by others) diet over the course of 24 days. Both diets, in turn, appeared superior to the shorter preplanned diet. However, this difference was not necessarily reflected in differences and changes in acceptability of individual foods. The relative absence of monotony effects suggested that the diet was not sufficiently austere to show appreciable differences among the experimental treatments, and indicated that, under some conditions at least, even a three-day menu cycle does not bring about pronounced adverse effects on consumption and preference.

PROBABLY EVERYONE can easily list several foods that he could eat day after day without tiring of them. Such a list would include not only staples but other foods that may appeal to a narrow range of the population, foods such as fried eggs, milk shake, potato chips, hamburgers. Similarly, almost everyone can name foods that, though very well liked, cannot be eaten more often than once every week or two without dissatisfaction setting in. Proneness to monotony is a dimension along which foods may be evaluated, and the point on this dimension where a food lies will depend on the specific individual and his experiences and physiological makeup, and on the physicochemical attributes of the food itself.

Empirical studies in this area have been few, and none have used experimental variations. In a study reported by Siegel and Pilgrim (1958), 79 college men subsisted for 22 days on two alternate daily menus consisting of canned Army rations. Among the conclusions of the study were: most foods decline in consumption and preference with repetitive eating, and there is little, if any, recovery with the passage of time; items having an initially high preference generally, but not always, show less decline in preference than items rated low initially; the rate of decline is partly a function of the specific food. Similar conclusions were reached by Schutz and Pilgrim (1958) in a study of soldiers who were limited to 41 different canned operational ration items for 37 days; but, apart from these two studies and minor questionnaire investigations on desired frequency of serving, evidence on monotony has been almost nil.

PROBLEM

The present exploratory experiment was an attempt to elucidate the important factors in food monotony. Two variables were selected for study. First was cycle length *per se*. To what extent does a more varied diet reduce monotony effects? Specifically, how much better is a 6-day cycle than a 3-day cycle? The second variable related to the possibility of controlling monotony effects. This possibility is supported by general psychological principles on the effectiveness of participation in producing more favorable attitudes and behavior. Is acceptance improved by having consumers plan their own menus as contrasted to the situation where outside experts have provided "best" menus from the same food supply?

METHOD

Subjects and general conditions. Subjects (*S*'s) were 72 enlisted personnel from groups permanently stationed at Fort Lee, Virginia. All had volunteered for the test and were promised administrative leave at the conclusion, for their cooperation and as compensation for the weekend passes they would miss. Their median age was 21, their average education was about 3rd year of high school, and about 84% had 6–18 months of Army service. A questionnaire administered prior to the test indicated that only 11 had low morale or an unfavorable attitude toward the Army. The general activity level was moderate, including organized athletics, physical training, and routine work details. The test was run in October, 1959, and continued for 24 consecutive days. One *S* from each experimental treatment dropped out before the test was completed, but for causes not related to the test.

Foods and menus. Forty-eight foods (including such staples as bread, jam, coffee, margarine) were provided for the 3-day cycle treatment, and these, plus 32 others, for the 6-day cycle. Generally, selection was limited to foods requiring little or no preparation.

There were 4 types of items: a) canned components of military rations, including ready-to-eat meat items, fruits, and baked goods; b) precooked dehydrated foods, including meats, soups, desserts, and fruits, some of which were in the experimental stage; c) commercially available foods such as canned vegetables and soups, and candy bars; d) experimental high-protein, high-calorie beverages.

A 3-day feeding cycle and a 6-day cycle were devised from these components. Each day there were the 3 usual meals, plus an evening snack. In each set of menus, any main dish, soup, or vegetable was served only once. Some starches and fruits were served more than once during a cycle, though the ratio of items within each food type was maintained at about 2:1 for the two cycle lengths. The number of calories provided per daily menu averaged about 4,000.

Table 1 lists the foods and the number of times each was served in each experimental treatment. Except for two foods that required trained cooks, the men in each subgroup prepared their own foods.

Experimental plan. The 72 *S*'s were randomly assigned to 3 experimental treatments; the 24 *S*'s in each treatment were, in turn, randomly assigned to four 6-man subgroups.

Treatment 1—3-day cycle, self-planning of menus. During the first cycle only, *S*'s were served the preplanned menus in order to familiarize them with the foods. Menus for the succeeding 7 cycles were planned by each 6-man subgroup separately, using the same foods in the same quantities as in the first cycle.

[a] This paper reports research undertaken at the Quartermaster Food and Container Institute for the Armed Forces, and has been assigned Number 2029 in the series of papers approved for publication. This research was supported in part by the United States Air Force under Contract No. MIPR (33-616) 59-19, monitored by Aero Medical Laboratory, Directorate of Research, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. The views or conclusions are those of the authors. They are not to be construed as necessarily reflecting the views or indorsement of the Department of Defense.

[b] Presented at the Twentieth Annual Meeting of the Institute of Food Technologists, May 18, 1960, San Francisco, California.

Treatment 2—3-day cycle, preplanned menus. All preplanned menus were repeated *in toto* and in the same order in each of the eight cycles.

Treatment 3—6-day cycle, preplanned menus. This treatment differed from Treatment 2 only in the greater number of different foods and in that there were only four cycles.

Measurements. *Preference and consumption.* After every meal, including the snack, each *S* completed a questionnaire indicating how much, to the nearest one-third of a portion, he ate of each food served, and how much he liked it (Peryam and Pilgrim, 1957). Test team members checked the questionnaires for accuracy of the consumption estimate. Preference for each "meal-as-a-whole" was also included on the questionnaire.

Weight. *S*'s were weighed 3 days before the test began, and every six days thereafter.

Pretest questionnaire. A questionnaire was administered a few days before the start of the test to obtain information on each *S*'s background and his morale and attitude toward the test.

Terminal questionnaire. A questionnaire was administered the day after completion of the test. It sought opinions about the feeding systems, *S*'s personal reactions, and attitudes toward the test and toward the Army.

RESULTS

Weight changes and health. Almost as many *S*'s lost weight as gained weight; the over-all effect was no change. Differences among treatments could be attributed to chance fluctuations. Nor was there any evidence that health was adversely affected.

Terminal questionnaire. Evaluation of dietary. *S*'s in Treatment 2 (3-day, preplanned) considered the diet significantly less satisfactory ($p < .01$) for two months' continuous use in the field than did the men in the other two treatments, but the difference between the 3-day self-planned and the 6-day preplanned treatments was not significant. The data also suggest that more *S*'s in the self-planning treatment than in the other two treatments were in favor of leaving the ration as it was. Similarly, the self-planning *S*'s thought they could live longer on this ration and nothing else than did the other *S*'s ($p < .01$).

Thus, it appears that the most dissatisfied *S*'s were those assigned to the shorter cycle *and* preplanned menus. Self-planning induced beliefs that soldiers should be expected to subsist on this ration for a longer period. One might conclude that self-planning does as much to increase satisfaction with the rations as does almost doubling the number of different foods, and also extends the period that *S*'s believe men should be expected to live on them.

However, increasing the number of foods does seem to reduce desire for foods not provided. This is shown by the significantly ($p < .05$) fewer *S*'s in the 6-day cycle who said they developed strong desires or cravings for foods that weren't available: 22%, compared to an average of 67% in the 3-day cycle treatments. Fresh meats, fresh milk, and eggs were the foods most desired.

Generally, *S*'s felt they had enough to eat. Forty-nine preferred the canned to the dehydrated components, one preferred the dehydrated, and the remaining 19 had no preference.

Personal reactions. Those who planned their own menus had a significantly higher level of morale ($p < .05$) during the test than did those in either of the preplanned menu groups. The latter two did not differ significantly from each other. No significant differences were found between treatments on general attitude toward the Army or on "happiness in participating" in the test.

Unauthorized consumption. An attempt was made to determine whether the men had consumed unauthorized foods and beverages, and, if so, how much. The *amount* of reported unauthorized consumption averaged 2, 9, and 4 calories per man per meal for the three treatments, respectively. These numbers correspond to 0.2%, 1.0%, and 0.4% of total caloric intake.

However, 75% of the *S*'s, according to their own statements, consumed foods or beverages (including extra coffee) other than those issued. The highest percentage was for Treatment 2 (3-day, preplanned) where 96% had "defected," a percentage that was significantly higher ($p < .05$) than for the other two treatments, which did not differ significantly from each other. Note that the most restrictive treatment was associated with the most cheating.

How serious is this fact as it bears on the interpretation of the results? Certainly, it is a contaminating factor. One might speculate that unauthorized consumption would lead to decreased consumption of foods that *were* scheduled. But, generally, over-all consumption of scheduled foods was high, which suggests that the amounts of unauthorized foods, averaging less than 1% of total intake, were of little importance.

Basic preference and consumption data for individual foods. Preference and consumption means were calculated by food, treatment, and cycle. The successive categories of the hedonic scale were assigned the values 1–9, beginning with "dislike extremely." Consumption was the average per cent eaten of a normal serving.

Exclusion of S's. For most foods, not every *S* indicated his preference on all cycles. Sometimes the failure was due to error, sometimes to the *S*'s absence from an entire meal at which the food was served. It is probable that these individuals were the ones most adversely affected by repetitive diets. To exclude consumption and preference values only from the cycle on which their ratings were not available could be misleading since the consumption and preference averages—based on those less adversely affected—would be spuriously increased. Thus, the "self-selection," being absent or not rated, might mask downward trends in preference and consumption over time to the extent that those who don't like a food are the least likely to be represented in the averages. Siegel and Pilgrim (1958) present empirical evidence in support of this contention. It was felt that the biasing effect might best be reduced by excluding an *S* from all cycles if he missed at least one. By the same reasoning, this exclusion might bias the *level* of rating upwards; however, this biasing was not considered as serious as the other because interest was focused on the trend of preference and consumption, not only on the level of preference and consumption *per se*.

Accordingly, if a subject failed to indicate preference or consumption of a food, none of his preference and consumption values were used in the calculations for any cycle. The exception occurred when an *S* ate "none or almost none" and did not give a preference rating. Then, his mean rating was taken as the average rating of the food by those in the same treatment who also ate "none or almost none," provided that one of the following criteria were met:

a) The *N* of those who *did* rate was 9 or more.

b) The *N* of those who *did* rate, if less than 9, was at least as large as the *N* of those who did not rate.

This correction procedure tends to minimize the upward bias that would have been present by eliminating those who ate none or almost none and logically did not rate. Before a food was considered for tabulation and analysis, it had to have a minimum of 15 preference and consumption values per cycle per treatment.

Summary of results. The consumption and preference data for each food were tabulated by first and second halves of the experiment (Table 1). No general declines or increases in consumption or preference were apparent over time, and only a limited number of foods demonstrated any marked changes or even the same trend in all three treatments. For Treatment 1, consumption of 29% of the foods increased by at least three percentage points (or 1/10 of the unit of measurement), 65% decreased, and 6% remained the same. The percentages for Treatment 2 were 28% increase, 45% decrease, and 27% no change; and for Treatment 3 they were 31%, 40%, and 29%.

In Treatment 1, preference for 42% of the foods increased by at least the minimal amount of 0.1 scale points, 35% decreased, and 23% showed no change. In Treatment 2, 41% increased, 45% decreased, and 14% showed no change; and

Table 1. Individual foods: type, number of times served per cycle, and consumption and preference ratings for first and second halves of experiment.

Food and type code[a]	Treatment/ times served/N[b]	Mean % consumed		Mean preference	
		1st half	2d half	1st half	2d half
Juices and fruits					
Apple juice C,Com	3/1/23	97	97	7.7	7.6
Applesauce D, Mil	3/1/23	87	90	7.3	7.4
Apricots C, Mil	1/1/[c]				
	2/1/22	93	87	7.3	7.1
	3/1/23	97	93	8.0	7.9
Apricots D, Mil	1/1/[c]				
	2/1/21	73	67	5.9	5.9
	3/1/21	90	83	7.3	7.1
Apricot nectar C,Com	3/1/22	100	100	8.2	8.0
Fruit compote D,Mil	1/1/17	63	67	6.6	7.2
	2/1/23	60	57	5.8	5.9
	3/1/22	80	80	6.4	6.7
Fruit cocktail C,Mil	1/2/[c]				
	2/2/38	97	97	8.2	7.9
	3/1/46	100	100	8.3	8.2
Grapefruit juice D,Mil	3/1/22	97	97	7.1	7.3
Grape juice C,Com	1/1/17	97	87	7.4	7.5
	2/1/15	100	100	7.5	7.2
	3/1/22	100	93	7.4	7.3
Orange juice C,Com	1/1/16	90	97	7.7	8.0
	2/1/20	93	100	7.2	7.3
	3/1/22	100	100	8.1	8.0
Orange juice D,Mil	1/1/[c]				
	2/1/16	97	100	7.1	7.5
	3/1/23	100	97	7.7	7.7
Orange-grapefruit blend C,Com	1/1/17	87	73	6.8	6.5
	2/1/22	80	83	6.2	6.4
	3/1/22	93	100	7.9	7.5
Peaches C,Mil	1/1/23	90	90	8.2	8.2
	2/1/20	100	100	8.1	8.0
	3/1/23	100	100	8.2	8.1
Pears C,Mil	3/2/44	97	100	8.3	8.2
Pineapple C,Mil	1/1/16	93	83	7.9	7.9
	2/1/21	97	97	7.9	7.9
	3/1/21	97	97	8.3	8.1
Pineapple juice C,Com	3/1/23	100	93	7.9	8.0
Tomato juice C,Com	3/1/20	93	97	7.9	7.9
Potatoes and starches					
Cereal bar D,Mil	3/2/34	60	47	6.2	5.9
Macaroni D, Mil	3/1/23	83	70	6.8	6.4
Mashed potatoes D,Mil	1/2/[c]				
	2/2/36	63	73	6.4	6.6
	3/2/40	70	73	6.8	7.1
Oatmeal D,Mil	1/1/18	77	83	7.4	7.6
	2/1/22	57	63	6.0	6.2
	3/1/23	80	63	7.0	6.6
Potato sticks C,Mil	1/1/[c]				
	2/1/22	37	73	6.3	6.7
	3/2/42	56	77	7.1	7.4
Rice D,Mil	1/1/15	83	73	7.1	6.9
	2/1/22	53	50	4.6	4.8
	3/2/46	63	73	6.2	6.8
Soups					
Beef drink E,P	3/1/23	33	17	4.5	3.7
Beef soup C, Com	3/1/23	93	100	8.1	8.1
Chicken rice soup D,Mil	3/1/23	93	87	7.5	7.5
Cream of mushroom soup C,Com	3/1/21	73	73	6.1	6.2
Pea soup D,Mil	1/1/17	40	23	5.1	4.7
	2/1/20	30	20	3.2	2.7
	3/1/22	67	53	6.1	5.4
Tomato soup C,Com	1/1/17	90	73	8.0	8.0
	2/1/22	90	87	7.9	7.6
	3/1/23	93	87	7.7	7.7
Vegetable soup C,Com	1/1/22	90	77	7.9	7.9
	2/1/20	93	90	8.0	7.7
	3/1/23	93	97	8.2	8.2
Candies and desserts					
Butterscotch pudding D,Com	1/1/17	70	73	7.0	7.1
	2/1/22	60	87	5.6	7.0
	3/1/23	97	97	8.2	8.1
Candy bar, chocolate nougat Com	1/1/15	97	100	7.7	7.9
	2/1/21	97	100	7.7	8.2
	3/1/23	100	97	8.1	8.1

Table 1 (continued)

Food and type code[a]	Treatment/ times served/N[b]	Mean % consumed		Mean preference	
		1st half	2d half	1st half	2d half
Caramels Com	3/1/22	100	100	8.0	8.0
Chocolate chip cookies Com	3/1/19	93	100	8.5	8.3
Chocolate drops Com	1/1/16	63	90	7.3	7.9
	2/1/21	100	100	8.2	8.3
Chocolate fudge bar Com	1/1/[c]				
	2/1/20	100	100	7.8	7.6
	3/1/21	90	100	8.1	8.0
Chocolate pudding D, Com	3/1/23	100	100	8.1	8.2
Cranberry sauce C,Com	3/1/21	77	80	7.3	7.3
Dates Com	3/1/21	100	100	7.9	8.1
Fruit cake C,Mil	1/1/[c]				
	2/1/23	83	77	6.8	6.5
	3/1/23	77	87	7.3	7.6
Jelly sandwich Com	3/1/22	83	93	6.6	7.4
Jordan almonds Com	1/1/16	70	77	6.2	6.8
	2/1/22	93	97	7.4	7.5
	3/1/21	100	97	7.7	7.8
Macaroons Com	3/1/22	100	100	8.3	8.2
Orange-nut roll C,Mil	3/1/22	100	90	7.5	7.3
Peanut-butter snack C,Mil	1/1/[c]				
	2/1/22	100	100	7.9	8.0
	3/1/23	100	100	7.7	7.9
Pecan roll C,Mil	1/1/17	87	87	7.5	7.9
	2/1/22	73	80	6.5	6.9
	3/1/22	93	97	7.5	7.3
Peppermint drops Com	1/1/[c]				
	2/1/19	93	93	7.2	7.2
	3/1/19	90	100	8.1	8.2
Poundcake C, Mil	1/1/17	97	90	8.1	8.2
	2/1/21	93	93	7.7	7.7
	3/1/23	90	97	7.9	7.9
Raisins Com	1/1/17	73	70	6.3	6.7
	2/1/15	100	100	7.7	7.8
	3/1/21	100	100	8.1	8.0
Sugar wafers Com	1/1/16	87	93	7.9	7.8
	2/1/18	100	100	8.0	7.7
	3/1/23	100	100	8.1	8.0
Sour-ball candies Com	3/1/21	100	100	8.1	8.1
Toffee Com	3/1/22	100	100	8.0	8.0
Vanilla wafers Com	3/1/22	100	100	8.3	8.1
Bread and crackers					
Bread C,E	1/8/160	80	67	7.3	7.5
	2/8/112	63	57	6.3	6.3
	3/17/238	87	83	7.2	7.3
Crackers E	1/3/57	90	73	7.3	7.3
	2/3/38	97	97	7.6	7.6
	3/7/140	97	97	7.7	7.8
Vegetables					
Beans, green C,Com	1/1/16	93	87	7.9	7.9
	2/1/22	90	77	7.5	7.3
	3/1/23	87	80	7.6	7.5
Corn, whole kernel C, Com	3/1/21	83	93	7.4	7.6
Peas C, Com	3/1/22	87	77	7.8	7.2
Jelly & margarine					
Jelly Com	1/2/[c]				
	2/2/40	77	73	7.6	7.4
	3/5/75	80	90	7.9	8.0
Margarine Mil	1/7/133	83	73	7.6	7.6
	2/7/91	90	83	7.5	7.4
	3/13/210	87	90	7.8	7.8
Beverages					
Chocolate drink C,E	1/1/[c]				
	2/1/23	77	73	5.9	5.9
	3/2/44	97	93	7.2	7.4
Cocoa Com	1/2/[c]				
	2/2/38	77	73	6.5	6.9
	3/4/86	97	97	7.8	7.9
Coffee drink C,E	1/2/[c]				
	2/2/38	80	70	6.5	6.1
	3/1/42	57	60	4.8	5.1
Milk, non-fat D,Com	1/4/[c]				
	2/4/68	53	33	4.8	4.3
	3/9/117	97	90	7.3	7.4

Table 1 (concluded)

Food and type code[a]	Treatment/ times served/N[b]	Mean % consumed		Mean preference	
		1st half	2d half	1st half	2d half
Main dishes					
Prefried bacon C,Mil	1/1/22	87	77	7.4	7.3
	2/1/22	70	73	6.5	7.1
	3/2/44	93	97	7.7	7.6
Beef & onion gravy D,Mil	1/1/22	100	97	7.9	8.0
	2/1/23	90	80	7.1	6.6
	3/1/23	90	83	7.4	7.0
Beef & potato hash D,Mil	1/1/23	73	77	6.9	7.4
	2/1/22	53	43	5.2	4.6
	3/1/23	63	57	5.9	6.0
Beefsteak C,Mil	1/1/23	93	77	7.7	7.4
	2/1/17	93	97	7.0	7.2
	3/1/22	87	77	7.4	7.3
Sliced ground beef,tomato gravy D,Mil	3/1/21	70	67	6.8	6.8
Chicken, solid pack C,Mil	3/1/23	87	97	7.6	7.9
Chicken & gravy D,Mil	1/1/21	90	70	7.8	7.0
	2/1/22	90	70	7.6	6.6
	3/1/22	87	77	7.4	7.1
Chicken & noodles C,Mil	3/1/23	100	97	7.9	8.0
Ham & eggs C,Mil	3/1/23	80	70	5.7	6.2
Ham, fried C,Mil	1/1/23	97	80	7.5	7.1
	2/1/22	87	73	6.8	6.5
	3/1/23	90	80	7.2	6.8
Macaroni & cheese D,Mil	3/1/23	73	50	6.4	5.0
Peanut butter sandwich Com	3/1/22	87	83	7.3	7.4
Pork steak C,Mil	3/1/23	93	97	8.0	7.9
Shrimp & tomato sauce D,Mil	1/1/[c]				
	2/1/22	27	17	3.0	2.8
	3/1/23	27	30	3.5	3.5
Spaghetti with meat and tomato sauce C,Mil	1/1/23	100	90	8.1	7.7
	2/1/19	97	93	7.9	7.6
	3/1/23	100	100	7.9	7.8
Tuna C,Mil	3/1/23	97	93	7.7	7.9
Turkey C,Mil	1/1/17	93	83	8.0	7.9
	2/1/23	93	93	7.4	7.5
	3/1/22	97	90	8.1	7.9
Meal-as-a-whole	1			7.4	7.6
	2			6.8	6.9
	3			7.4	7.6

[a] Food type code: C—canned. Com—purchased commercially (national brand). D—dehydrated. E—experimental food. Mil—Military procurement. P—prepared as needed from canned ingredients.

[b] *N* is the number of ratings per cycle. An *N* greater than 23 means that the food was served more than once in each cycle.

[c] Preference and consumption data are too unreliable or incomplete to be presented.

in Treatment 3, 38% increased, 43% decreased, and 19% did not change.

It was felt that rigorous statistical analysis for each food was not warranted in view of the incomplete data, the number of inconsistent trends, the large number of foods showing no trend, and, as is shown later, the confounding of a food with menu combinations differing from treatment to treatment. Inspection methods were thought to be more useful in suggesting hypotheses about what foods appeared most susceptible to monotony effects. From a practical viewpoint, preference changes of less than 0.4 scale points, from the first to the second half of the experiment, and consumption changes of less than ten percentage points, are considered inconsequential.

Hence, in the succeeding paragraphs, only those foods are discussed where the trends were relatively consistent among treatments or where unusually large differences in consumption or preference were evident between the two halves of the experiment.

1) *Juice and fruits (17 items).* Most foods in this group showed no systematic trends. The levels of consumption and preference were high, with only fruit compote and dehydrated apricots having over-all mean ratings of less than 6.0. Canned apricots were higher in level of preference and consumption than were the dehydrated; but there were practically no differences between canned and dehydrated orange juice.

2) *Potatoes and starches (6 items).* Average consumption of all items within this group was about 2/3, despite the fairly high level of ratings. In view of the large number of calories provided in the menus, non-consumption of the starches is a reasonable and convenient way of limiting intake. Average preference (over all cycles) was less than 6.0 for only one food, steamed rice; and this occurred only for Treatment 2. In this treatment, rice was served with shrimp, the lowest-rating main dish; and it is possible that the low acceptance of shrimp affected evaluation of its accompaniment. In Treatment 3, rice was served with turkey as well as with shrimp; and, hence, it was not expected to be—and was not—as adversely affected as the rice was in Treatment 2. Potato sticks markedly increased in consumption in the two treatments for which data are available; an upward trend in preference is also suggested.

3) *Soup (7 items).* Pea soup consistently dropped in acceptability in all three treatments. The level of consumption and preference was particularly low in the three-day preplanned treatment. An experimental beef drink was the least consumed and second-least liked of all foods served to Treatment 3. During the course of the experiment its consumption dropped from a first-half average of 33% to a second-half average of 17%; likewise, preference declined by 0.8 scale points.

4) *Candies and desserts (23 items).* Preference and consumption were initially high for these items and often tended to increase. It may be concluded that candies and desserts present no problems in monotony.

5) *Bread and crackers.* Preference for canned bread and crackers remained fairly constant among all treatments, but consumption declined by about 17% in Treatment 1.

6) *Vegetables (3 items).* No problems in monotony were encountered for this group of foods.

7) *Margarine and jelly.* Preference for these two items averaged over 7.5 for each treatment, with little or no change over time.

8) *Beverages* (4 items; coffee and tea not included.) These products were generally of low acceptability in Treatment 2, and for reasons not readily apparent, both indices declined further over time.

9) *Main dishes (17 items).* Ten main dishes showed no consistent trends over time, even though a rise or fall in consumption and preference occurred occasionally: prefried bacon, beef and potato hash (dehydrated), sliced ground beef with tomato gravy (dehydrated), solid-pack chicken (canned), chicken and noodles (canned), peanut butter sandwich, pork steak (canned), spaghetti with meat and tomato sauce (canned), tuna (canned), and turkey (canned). Of course, these foods differed from one another in absolute level of acceptability, as can be seen in Table 1. The other seven main dishes are discussed individually.

a) *Beef and onion gravy (dehydrated).* Only in Treatment 1 were the high initial ratings maintained. The ratings for Treatment 2 declined by 0.5 scale points, and for Treatment 3 by 0.4 scale points.

b) *Beefsteak (canned).* Consumption dropped 18% in Treatment 1, and about 12% in Treatment 3, but no appreciable changes in preferences were apparent. Consumption never fell below 70%, and only on one cycle in one treatment did average rating fall below 7.0.

c) *Chicken and gravy (dehydrated).* Declines in consumption were evident: 22% in treatments 1 and 2, and 12% in Treatment 3. Despite the rather high first-half preferences (7.8, 7.6, and 7.4), the declines in preference were 0.8, 1.0, and 0.3 for the three treatments. The curves of preference suggest that there would be further loss with continued use.

d) *Ham and eggs (canned).* This food was served only in Treatment 3. Preference increased by 0.5 scale points over time. The decrease of about 12% in consumption is attributable almost solely to the low consumption on the last cycle, with no concomitant change in preference.

e) *Fried ham (canned).* Consumption dropped in all three treatments by 11–17%, and preference fell by 0.4 scale points in Treatments 1 and 3.

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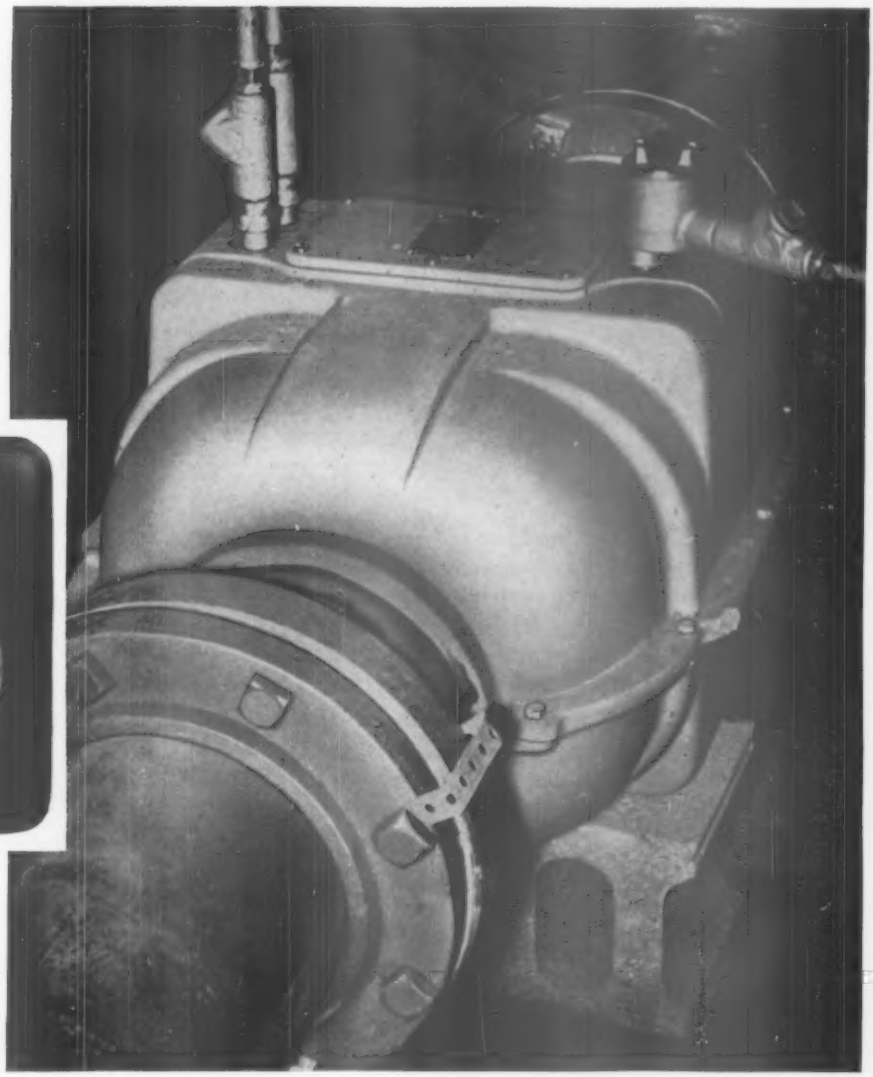

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f) *Macaroni and cheese (dehydrated).* This item, served only in Treatment 3, showed a 32% drop in consumption, and a drop in preference of 1.4 scale points.

g) *Shrimp and tomato sauce (dehydrated).* After their first experience with this food, the men in Treatment 1 often refused to place this item on the menu, so that adequate consumption and preference values for this group are not available. In the remaining two treatments, average consumption during any cycle was never greater than 33%, nor the average rating higher than 3.7. From any standpoint, this item is unacceptable, both initially and after experience.

The evidence, limited as it is, suggests that the dehydrated foods used in the test were somewhat more susceptible to monotony than the canned. This is shown by the subjects' answers in the summary questionnaire and by examination of the individual food data. For example, two types of canned chicken and one type of dehydrated chicken were served in each cycle to Treatment 3. Both canned types maintained their high acceptability, but the dehydrated did not. Inspection of other canned vs. dehydrated main dishes tends to confirm this suggestion.

Preference for the meal-as-a-whole. Despite inconsistent trends and levels of consumption and preference among treatments for individual foods, the ratings of the meal as a whole lend further support to the previous evidence that the self-planning treatment had more favorable attitudes toward the diet than did the preplanned treatment on the same cycle length. Subjects were asked to indicate their preference for each meal as a whole. The ratings for Treatments 1 and 3 were practically identical, those for Treatment 2 about 0.7 scale points lower. Thus it appears that satisfaction with a diet in general, and the meal-as-a-whole in particular, may not be strongly related to satisfaction with the individual components.

DISCUSSION

Over-all satisfaction with the diet, and consumption of and preference for most foods, were higher than was expected on the basis of other tests of individual components and studies of monotony. The fact that the subjects were volunteers, were treated courteously, and were promised a reward for participation probably contributed to favorable attitudes. Only for a decided minority of foods were downward trends in consumption and preference apparent; in fact, occasional upward trends emerged.

Over-all satisfaction appeared greater among those who planned their own three-day menu cycles than among those who were served preplanned menus; but the superiority of this method as applied to individual foods could not be demonstrated. The three-day preplanned treatment had a less favorable attitude and evaluation of the diet, but no clear-cut corresponding loss is apparent in acceptability of the individual foods. What are some of the possible reasons? First, within any treatment, the behavior of an individual was not independent of the behavior of the others in his group. One or more dominant individuals can affect the attitudes and other reactions of the majority. Similarly, differences in skill of preparation might show up as differences among subgroups and treatments; and despite random assignment of subjects to treatments, these and other "group effects" can still be expected. Statistically and experimentally, the responses are not independent, and no rigorous method is available to take into account the undetermined degree of dependence.

Second, the menu combinations differed from treatment to treatment, and, in Treatment 1, from cycle to cycle. Certainly, the "combination effects" can be separated neither from the initial differences among subjects in the different treatments nor from the main experimental variations themselves. Nevertheless, the data should be useful in evaluating the relative acceptability of items and their relative proneness toward monotony; and the differences among treatments can provide a rough estimate of the variability of the levels of consumption and preference.

Future research on repetitive diets should impose more severe restrictions on the subjects than was done here. Not only was the quality of most foods high to begin with, but more than one processing method was represented. Possibly the availability of both dehydrated and canned foods may have offered sufficient variety in flavor and texture to offset the availability of just a limited number of different items. A fruitful investigation would be a three-way comparison of an all-canned, an all-dehydrated, and a mixed diet.

Finally, the variable of self-planning shows promise of being a method for increasing satisfaction with food. The subjects demonstrated both the desire and the ability to do their own planning. A drawback of self-planning is that the men might discard certain foods entirely, a major reason for incomplete data from Treatment 1.

Acknowledgment

The experimental work was accomplished and supervised by Messrs. Thomas Burt and Elie Weeks, Food and Container Engineering Branch, Quartermaster Research and Engineering Field Evaluation Agency, Fort Lee, Virginia. To them and their staff we express our gratitude.

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Treatment of Onions with Gamma Rays: Effects of Delay between Harvest and Irradiation[a]

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SUMMARY

Hybrid onions of the Southport White Globe type were stored at 70°F before and after irradiation with various doses of Co^{60} gamma rays. In lots irradiated 2 weeks after harvest as little as 2 kilorads was sufficient to inhibit subsequent sprouting almost completely. When irradiation was delayed until 11 or 17 weeks after harvest, however, there was little inhibition by doses ranging from 2 to 250 kilorads. The highest dose increased losses from softening of the bulbs.

In 1950 Sparrow and Christensen (1950) reported that a small dose (4.5 kilorads) of X rays markedly inhibited the germination of seed potatoes. Brownell and co-workers (Univ. Mich., 1954) found that gamma irradiation decreased the sprouting of White Pearl onions and Yellow Dry (Bermuda) onions. Although they employed doses ranging from 6.5 to 39 kilorads, sprouting occurred in all lots and the effect of dose was not clear. They noted that, in the case of the White Pearl bulbs, irradiation sometimes appeared to accelerate the first appearance of sprouts, but that these early sprouts did not continue to grow. Dallyn *et al.* (1955) and Sawyer and Dallyn (1956), in contrast, found that 3.7 kilorads completely prevented sprouting in jumbo-size white and yellow strains of Sweet Spanish onions, and a dose of 7.4 kilorads was effective in bulbs of smaller size.

Because a practical process for controlling the sprouting of onions would enable the onion dehydration industry to operate over a longer portion of the year, an investigation was carried out at the Western Regional Research Laboratory on the effects of gamma irradiation on sprouting and decay in onions.

In a preliminary trial in the 1955–56 season, small lots of Southport White Globe onions were irradiated with 11 and 93 kilorads of Co^{60} gamma rays. The onions had been harvested about two months before treatment, and although no sprouts were visible externally, bulbs cut longitudinally showed well developed internal sprouts. During subsequent storage at about 70°F, sprouts appeared more quickly in both treated groups than in the unirradiated controls. At 54 days, 19% of the controls and 25% and 30% of the irradiated samples had sprouted. Because these observations differed so markedly from those of Dallyn *et al.* (1955), and even from those of Brownell and co-workers (Univ. Mich., 1954; pp. 104–106), a more thorough study was conducted the following season. This was primarily to test the hypothesis that the period between harvest and irradiation is of major importance in determining whether sprouting will be inhibited.

MATERIALS AND METHODS

The onions used were of the strain W-45, a hybrid similar to the Southport White Globe but maturing earlier and of slightly lower solids content. It is widely used for dehydration. The bulbs were grown near Wellington, Nevada, and harvested on October 18, 1956, 191 days after planting. About 460 lb of onions, previously sized to remove all but 2-to-3-inch bulbs, were sorted to eliminate about 3% (sprouted, double, or visibly damaged). The dry tops were trimmed off and the bulbs were randomly distributed to yield 15 experimental sublots (59–84 bulbs each) and 3 control sublots (125–149 bulbs each). These were kept in lug boxes stacked in a room where the temperature would remain relatively constant. Temperature and humidity were measured several times a week. During the following 6½ months the temperature averaged 70°F (S.D. = 1.8°F), and relative humidity averaged 46% (S.D. = 10%).

Twelve, 76, and 118 days after harvest, sets consisting of a control sublot and five experimental sublots were taken to the Stanford Research Institute, Menlo Park, Calif., for irradiation with Co^{60} gamma rays. These groups of sublots are respectively identified as Series I, II, and III. On each occasion the various experimental samples were given doses of 2, 5, 10, 50, and 250 kilorads at a rate of 13 kilorads per hour. They were then returned to storage. Thus the 18 sublots represented three dates of irradiation and six dose levels, and they were otherwise treated identically.

Ten representative onions from each sublot of Series I were marked at the time of the irradiation. They were weighed periodically during the period of 1 to 12 weeks after the irradiation to detect any changes in rate of weight loss that might be attributable to gamma-ray treatment.

Just before irradiation and at intervals of one or two weeks thereafter, the onions of each sublot were examined, and bulbs that had sprouted or spoiled were discarded. An onion was considered to have sprouted when a definite green sprout had extended at least ½ in. from the bulb surface. One was discarded as spoiled when it had become soft or spongy to the touch or when mold had penetrated beyond the outer layers of skin. Five per cent of the onions in Series II, and 36% of those in Series III, were thus discarded before treatment. Observations were continued for 190 days from the date of harvest.

RESULTS AND CONCLUSIONS

Series I (irradiated 12 days post-harvest). By the 190th day after harvest, 34% of the controls had been discarded as sprouted, and 28% as spoiled. One bulb of the sublot treated with 2 kilorads of gamma rays, and one bulb of the 5-kilorad sublot had sprouted. Sprouting was completely prevented in all the other irradiated samples. Spoilage was 24–42% in the groups irradiated at 2–50 kilorads; there

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[b] A laboratory of the Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

was no trend with dose. The sublot treated at 250 kilorads showed 67% spoilage during the same period.

The weight loss of onions from the irradiated sublots during an 11-week period averaged 6.8% (5.2–8.2%); there was no trend with the dose. The control sample lost 7.7%. The difference between this figure and 6.8% is probably not significant.

Series II (irradiated 76 days post-harvest). The sprouting and spoilage in this series are shown in Fig. 1. Though some suppression of sprouting resulted from all of the radiation treatments, in no case was it complete. No clear-cut trend of inhibition with dose is apparent. A few weeks after irradiation, the 250-kilorad sublot showed a temporary acceleration of sprouting relative to the control—an effect noted in our preliminary experiment and in an experiment of Brownell and co-workers (Univ. Mich., 1954; p. 66). Spoilage was much greater in the 250-kilorad sample than in those receiving smaller doses, and this will more than account for the apparent inhibition of sprouting in this sublot.

Series III (irradiated 118 days post-harvest). In this series the fraction of onions discarded because of sprouting varied between 55% (2-kilorad dose) and 131% (50-kilorad dose) relative to the controls. The 50- and 250-kilorad samples showed accelerated sprouting a few weeks after irradiation. The rate of spoilage did not differ greatly except that the onions that had received 250 kilorads spoiled rapidly in the last month of the study. In this sublot 64% spoiled and 32% sprouted; in the control group 33% spoiled and 45% sprouted.

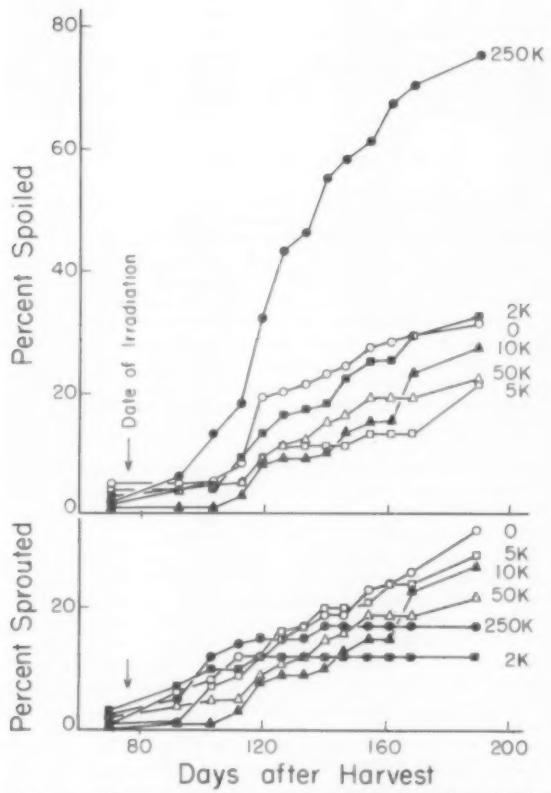

Fig. 1. Course of spoilage and sprouting in onions (Series II) irradiated 76 days after harvest. Percentages are based on the original number of bulbs in each sublot.

The difference in response between Series I, on the one hand, and Series II and III is striking and quite unlike the behavior observed in potatoes (Hendel and Burr, 1961). When the treatment took place 12 days after harvest, even 2 kilorads were sufficient to prevent sprouting almost completely. But when irradiation was delayed 9 or 15 weeks longer, a dose 125 times as great did not inhibit sprouting significantly, and may even have accelerated it temporarily. We believe that the divergent results of previous workers (Dallyn *et al.*, 1955; Sawyer and Dallyn, 1956; Univ. of Mich., 1954) may well have been due in part to differences in the period between harvest and irradiation.

A dose of 250 kilorads accelerated breakdown of the onions, but the lower doses did not. Irradiation shortly after harvest did not appreciably affect the rate of weight loss of onions during the following 3 months.

If irradiation were to be considered as a means of prolonging the processing season for the onion dehydration industry, gamma-ray treatment would have to be carried out shortly after harvest. Under these conditions a dose of 2 kilorads or less might be sufficient to assure adequate control of sprouting.

Acknowledgment

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The Determination of Soluble Solids in Citrus Juices. II.

Correction of Refractometer Values of Concentrated Juices

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SUMMARY

The results of analyses of a series of commercial and experimental citrus juice concentrates were presented and corrections for each component were applied to the refractometer value of each concentrate. Components for which analyses were made included citric acid, glucose, fructose, sucrose, soluble pectin, soluble nitrogenous materials, ash, potassium, water-insoluble solids, soluble solids, and total solids.

By applying corrections for each of the 7 components found to have an important effect on refraction, the accuracy of estimating soluble solids from refractometer values was distinctly improved over the accuracy from the currently used method of correcting observed values only for acid to degrees Brix. For concentrated orange juices the multiple correction method gave estimated soluble-solids contents averaging only 0.21% solids higher than soluble solids as determined by vacuum drying, compared to an average of 1.77% solids too high with the currently used method. For concentrated grapefruit juices, the multiple correction method gave results averaging only 0.04% too high, compared to 0.91% with the currently used method.

There was no important difference in the precision of results, whether the observed values were corrected for 7 components or only for acid, or were uncorrected.

THE EFFECTS of various nonsucrose components of citrus juices on refractometer values are described in the first paper of this series (Scott *et al.*, 1960), and corrections to soluble solids were established for those having significant effect. In this paper, corrections are applied to a series of refractometer readings on specific commercial and experimental concentrates whose compositions have been determined by analysis. Corrected refractometer values are compared to soluble-solids contents as determined by vacuum drying.

EXPERIMENTAL

Selection and Preparation of Samples. A series of frozen concentrated orange juices were obtained from five commercial producers, the samples selected to represent various periods of the 1955–56 season. Each sample was six 6-oz cans produced within a week, but not necessarily from the same lots of fruit. Contents of the six cans were thawed, thoroughly blended, repackaged in 4-oz cans, and stored at 0°F until required for analysis. Twenty-one of the commercial samples were 4-fold concentrates (nominally 42° Brix), and 11 samples were of higher density, taken from bulk storage specifically for this study. One sample was concentrated in the laboratory from canned orange juice that had been brought to our attention as being very unusual in composition.

The 33 samples were divided into three groups according to the time of season they were packed. Since 4-fold concentrates contained addback (high-density concentrate produced earlier or held in frozen storage from the previous season, then blended with current production for improvement in color or flavor), each sample may not be completely representative of the period indicated. For additional information on the effect of variety on composition, two samples each of concentrated juice prepared in the laboratory from Hamlin, Pineapple, and Valencia oranges were selected for analysis. Also, one sample of concentrated juice of Blood oranges and one of Valencia oranges were obtained from commercial producers in California for analysis and compositional comparison with Florida orange juice.

Concentrated grapefruit juice samples, sweetened and unsweetened, were obtained from 5 commercial producers. Unsweetened juice was also obtained from 2 canning plants and concentrated in the laboratory. A total of 10 grapefruit concentrates were analyzed. Concentrated tangerine juices were obtained from 3 producers, 2 samples sweetened and 2 unsweetened.

METHODS OF ANALYSIS

Soluble Solids by Vacuum Drying. Soluble solids are defined as those solids remaining in single-strength juices or diluted concentrates after insoluble solids have been separated by centrifugal force. Portions of concentrate weighed to 0.005 g (25 g of 42° Brix or 20 g of 55° Brix) were diluted to 200.0 ml and centrifuged in 50-ml stoppered conical tubes for 20 minutes at 1600 rpm with a tip radius of 10 in. Fifteen-ml portions of the supernatant were pipetted into a tared weighing dish with acid-washed sand. All volumetric measurements were conducted at 20°C. Visible moisture was removed by drying in a current of warm air, then the dishes were placed in a vacuum oven and dried for 30 hours at 60°C under a pressure of less than 75 mm of mercury. The 30-hour drying period was selected after measuring moisture losses at 2-hour intervals between 20 and 48 hours. After 28 hours the moisture loss was negligible. All determinations were made in triplicate, variations between replicates usually being less than 0.1% solids.

Water-Insoluble Solids. The solids that were separated by centrifuging from two 50-ml portions of diluted concentrate as described above were twice suspended in hot water and resedimented by centrifugation. The solids in each tube were then suspended in 66% isopropanol, centrifuged, and washed onto a single tared Gooch crucible with asbestos mat, using additional small portions of the same solvent. After the asbestos mat and solids were sucked dry, the crucibles and contents were placed in the vacuum oven and dried for 21–24 hours at 60°C and less than 75 mm pressure. Average variation between duplicates was 0.03% solids, with a maximum variation less than 0.1%.

Total Solids by Drying. Total solids were determined in a manner similar to that for soluble solids except that about 5 g of concentrate, weighed to the nearest milligram, were added to the sand and dispersed with hot water before drying. Duplicates usually varied by less than 0.1% solids.

Refractometer Brix. Refractometer values were determined with a Precision Refractometer at 20°C as described previously (Scott *et al.*, 1960).

Titratable Acidity. About 5 ml of concentrate were weighed

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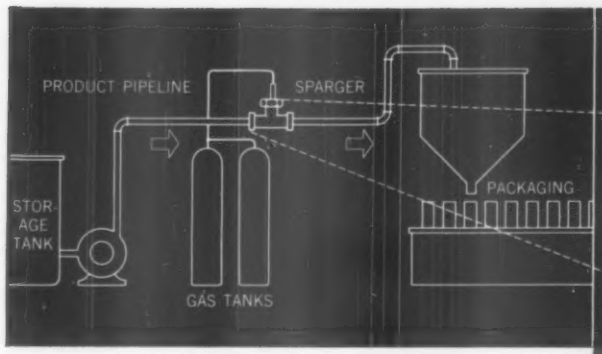

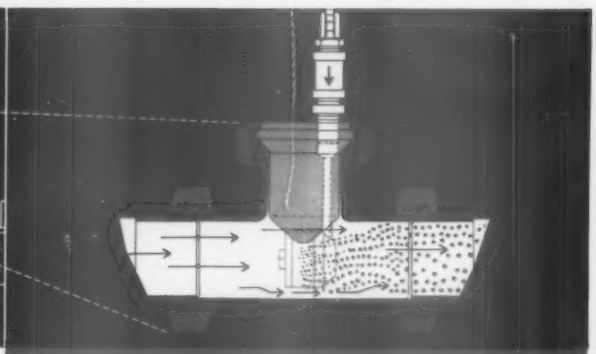

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to the nearest milligram and titrated electrometrically to pH 8.0 with sodium hydroxide.

Sugars. Fructose, glucose, and sucrose were determined by reduction of alkaline ferricyanide and colorimetric estimation of resultant ferrocyanide as described by Ting (1956).

Soluble Nitrogenous Compounds. Insoluble solids and pectinous materials were removed by diluting a weighed sample (about 20.00 g) of concentrate with water and ethanol to make 100.0 ml containing 50–60% alcohol, and centrifuging. Fifty ml of the supernatant were subjected to Kjeldahl digestion and diluted to 200.0 ml, and a 20-ml portion was distilled from alkali into boric acid solution. The percentage of soluble nitrogen in the sample was converted to approximate amino acid content by multiplying by 5.8, which is the average ratio to nitrogen reported by Underwood and Rockland (1953) for the amino acids in orange juice. A comprehensive study of the amino acid composition of Florida citrus juices was beyond the scope of this investigation.

Ash. Samples were reconstituted to about single strength, and the refractometer sugar scale values observed. Since this study is concerned with soluble materials only (except pulp *per se*), the samples were allowed partially to clarify at room temperature, and the insolubles were separated by centrifuging. One hundred milliliters of supernatant were transferred to a platinum dish, evaporated, and ashed by an official method of the *A.O.A.C.* (1955, 29.13). Ash was calculated as percentage of solids as indicated by the refractometer.

Mineral Citrates. Ash obtained above was analyzed for potassium by the official short gravimetric chloroplatinate method (A.O.A.C., 1955, 20.21b). Citrate contents of the concentrated juices were estimated from their observed potassium contents.

Potassium, calcium, and magnesium citrates in orange juice, calculated from published mineral analyses (Burger *et al.*, 1956), exist in the proportions of 83, 11, and 6 parts, respectively (Scott *et al.*, 1960). In this mixture the ratio of the citrates to potassium is approximately 3.16:1. Multiplication of the weight of potassium found by analysis of ash by 3.16 gives the approximate weight of citrates that existed in the soluble solids of the sample prior to ashing. This quantity, in turn, was used to calculate the percentage of metallic citrates in the original concentrate.

Soluble Pectin: Each weighed sample of about 25.00 g was diluted with water, comminuted for 3 minutes in a high-speed blender, deaerated, and made up to 200.0 ml. A portion of the diluted sample was centrifuged for 20 minutes in a closed 50-ml tube at 1600 rpm with a tip radius of 10 in. Pectin was separated from a 15.0-ml portion of the supernatant by treatment with hot ethanol and then taken up with water, as described by Rouse and Atkins (1955). Pectin as anhydrogalacturonic acid was determined colorimetrically as described by the same authors, except that 21 seconds were required for the addition of 6 ml sulfuric acid to the carbazole-containing sample, and matched test tubes were used for reading optical density in a Lumetron Model 401 colorimeter equipped with a 530-mμ filter (the mention herein of trade products does not imply that they are recommended by the Department of Agriculture over similar products not mentioned). Results are reported as per cent anhydrogalacturonic acid.

Refractometer Corrections for Nonsucrose Components. The first paper of this series described the differences between the refractometer sugar scale values of each nonsucrose component and sucrose solutions of equal concentrations in the ranges in which they occur in citrus juice products. Differences were plotted against concentration for reducing sugars, citric acid, metallic citrates, amino compounds, pulp, and pectin, giving correction curves for each component. Flavonoids were estimated to require a constant correction of about −0.12% solids. Ascorbic acid and peel oil showed negligible effect on refractometer values of citrus juice products. Following analyses of the series of concentrated juices, corrections for each component were obtained from the appropriate curve and totaled for each sample. The total correction was applied to the refractometer value of each sample, and the result compared with its soluble-solids content as determined by vacuum drying.

RESULTS AND DISCUSSION

Composition. The results of sugar analyses of the concentrated citrus juices are shown in Table 1. Sample 1 was a concentrate prepared in the laboratory, whereas samples 2–33 were commercially concentrated orange juices. Samples of the 600 series were laboratory concentrates from oranges of known variety, and were analyzed only for sugars. Sample CB was a bulk concentrate of California Blood orange juice, and sample CV was a bulk concentrate of California Valencia orange juice. Among the letter-coded samples, "T" signifies tangerine, "G" grapefruit, "U" unsweetened, and "S" sweetened concentrates. In the original analyses of these samples, soluble solids were determined by difference between insoluble solids and total solids determined by vacuum drying. Later it was determined that this indirect method was not accurate enough for use as the criterion for judging adequacy of refractometer corrections. Therefore, the data were discarded and soluble solids were determined directly by vacuum drying concurrently with determinations for water-insoluble solids and pectin. By this time, orange samples No. 8, UT-1, UG-6, and SG-4 had been lost. For determining percentage composition of these four concentrates, uncorrected refractometer readings were used as approximations of soluble-solids contents.

In the orange samples, fructose was usually present in slightly greater quantity than glucose, whereas sucrose made up more than half of the total sugars. These sugars averaged more than 80% of the soluble solids in concentrated orange juice. Differences in sugar composition from various seasons of the year were small, but averages indicated a seasonal trend toward an increased proportion of reducing sugars in total sugars and a decrease in percentage of total sugars in soluble solids. The California samples (CB and CV) contained higher percentages of reducing sugars than the Florida samples.

In concentrated tangerine juices, the relative proportions of reducing sugars were lower and sucrose higher than in concentrated orange juices, whereas total sugars made up about the same percentage of soluble solids.

Reducing sugars were subject to wider variations in concentrated grapefruit juices than in orange. Variation was widest in glucose content, which, in contrast to orange, was usually higher than fructose content. In unsweetened grapefruit concentrates, sucrose made up only 41% of the sugar components, compared to an average of more than 52% in orange concentrates. The percentage of sugars in soluble solids was about the same for orange and grapefruit concentrates.

Table 2 lists the nonsucrose components of each concentrate, as well as total, soluble, and water-insoluble solids. The average water-insoluble solids content of all orange concentrates was 0.86%, which is in good agreement with the average difference of 0.84% between total solids and soluble solids.

There was less variation in citric acid than in any of the other components analyzed. This was probably

Table 1. Sugars in Florida frozen concentrated citrus juices.

Sample no.	% soluble solids	% of concentrate				% of total sugars			% of soluble solids
		Glucose	Fructose	Sucrose	Total	Glucose	Fructose	Sucrose	Total sugars
Early-season orange pack									
1	42.85	7.70	7.71	23.33	38.74	19.88	19.90	60.22	90.41
2	40.68	6.15	7.75	19.57	33.47	18.37	23.16	58.47	82.28
5	40.09	7.90	8.13	15.67	31.70	24.92	25.64	49.43	79.07
14	40.64	8.06	8.46	17.81	34.33	23.48	24.64	51.88	84.47
15	40.20	8.22	8.18	17.80	34.20	24.04	23.92	52.05	85.07
20	40.47	7.84	8.09	17.29	33.22	23.60	24.35	52.05	82.09
21	40.53	7.70	8.50	15.58	31.78	24.23	26.75	49.02	78.41
29	40.80	8.49	8.24	17.32	34.05	24.93	24.20	50.87	83.46
32	40.08	6.13	8.21	18.67	33.01	18.57	24.87	56.56	82.36
8	55.80[a]	11.07	11.86	23.31	46.24	23.94	25.65	50.41	82.87
26	55.77	10.53	10.69	24.81	46.03	22.88	23.22	53.90	82.54
30	55.96	10.42	11.04	24.80	46.26	22.52	23.87	53.61	82.67
625	....	7.14	7.67	20.19	35.00	20.40	21.91	57.69	....
634	....	7.77	7.64	16.17	31.58	24.60	24.19	51.20	....
				Average		22.60	24.02	53.38	82.98
Mid-season orange pack									
3	40.60	6.42	8.03	19.25	33.70	19.05	23.83	57.12	83.00
6	40.73	8.57	8.13	17.53	34.23	25.04	23.75	51.21	84.04
16	40.14	8.28	7.97	17.52	33.77	24.52	23.60	51.88	84.13
17	40.26	8.10	7.72	18.45	34.27	23.64	22.53	53.84	85.12
22	40.70	8.73	8.12	18.73	35.58	24.54	22.82	52.64	87.42
23	41.42	7.82	8.27	15.88	31.97	24.46	25.87	49.67	77.18
9	55.90	10.65	11.25	24.41	46.31	23.00	24.29	52.71	82.84
10	56.04	9.96	10.73	24.51	45.20	22.04	23.74	54.45	80.66
11	43.29	8.06	8.37	19.36	35.79	22.52	23.39	54.09	82.67
27	56.25	8.98	11.70	20.82	41.50	21.64	28.19	50.17	73.78
637	....	8.70	8.53	16.25	33.48	25.99	25.48	48.54	....
658	....	9.00	8.33	16.25	34.14	26.36	24.40	49.24	....
				Average		23.57	24.32	52.13	82.08
Late-season orange pack									
4	40.63	8.23	8.08	17.61	33.92	24.26	23.82	51.92	83.49
7	40.65	7.90	8.06	15.47	31.43	25.14	25.64	49.22	77.32
18	40.60	8.06	7.46	15.29	30.81	26.16	24.21	49.63	75.89
19	40.18	8.44	8.10	17.25	33.79	24.98	23.97	51.05	84.10
24	40.83	8.43	8.30	17.67	34.40	24.51	24.13	51.37	84.25
25	40.84	8.28	8.22	17.23	33.73	24.55	24.37	51.08	82.59
33	39.78	6.86	7.88	16.69	31.43	21.83	25.07	53.10	79.01
12	56.14	10.95	11.75	22.93	45.63	24.00	25.75	50.25	81.28
13	51.63	9.96	10.65	21.08	41.69	23.89	25.55	50.56	80.75
28	56.47	11.07	11.62	23.26	45.95	24.09	25.29	50.62	81.37
31	57.55	10.74	11.97	23.57	46.28	23.21	25.86	50.93	80.42
672		7.65	8.44	18.05	34.14	22.41	24.72	52.87	
677		7.58	8.02	18.46	34.06	22.25	23.55	54.20	
CB		11.52	12.77	17.92	41.97	27.45	30.43	42.70	
CV		11.08	11.42	19.58	42.07	26.34	27.15	46.54	
				Average (Except CB and CV)		23.94	24.76	51.29	80.95
Tangerine and grapefruit packs									
UT-1	42.44[a]	8.02	6.87	20.47	35.36	22.68	19.43	57.89	83.32
UT-2	40.57	6.76	7.12	19.73	33.61	20.11	21.18	58.70	82.84
ST-1	40.54	6.97	7.04	20.32	34.33	20.30	20.51	59.19	84.68
ST-2	41.74	5.56	6.91	21.17	33.64	16.53	20.54	62.93	80.59
UG-1	40.24	11.41	8.58	12.69	32.68	34.91	26.25	38.83	81.21
UG-2	40.29	14.19	6.30	14.31	34.80	40.78	18.10	41.12	86.37
UG-3	38.72	8.99	8.54	13.43	30.96	29.04	27.58	43.38	79.96
UG-4	59.01	12.83	13.59	19.55	45.97	27.91	29.56	42.53	77.90
UG-5	38.23	9.60	8.76	12.86	31.22	30.75	28.06	41.19	81.66
UG-6	42.36[a]	13.22	7.78	13.62	34.62	38.19	22.47	39.34	81.73
UG-Average						33.60	25.34	41.07	81.47
SG-1	37.99	9.13	8.37	14.67	32.17	28.38	26.02	45.60	84.68
SG-2	40.85	8.57	7.66	18.38	34.61	24.76	22.13	53.11	84.72
SG-3	42.44	8.10	7.66	19.62	35.38	22.89	21.65	55.46	83.36
SG-4	43.73[a]	7.73	6.92	22.10	36.75	21.03	18.83	60.14	84.04
SG-Average						24.27	22.16	53.58	84.20

[a] Uncorrected refractometer values.

influenced by blending in processing for control of solids/acid ratio.

The sums of glucose and fructose contents are shown in these tables because, with few exceptions, total reducing sugars are subsequently used as the basis for one of the refractometer corrections.

Pectin content (AGA) is to some extent subject to processor control, being related to extraction pres-

Table 2. Nonsucrose components of Florida frozen concentrated citrus juices.

Sample no.	Per cent solids by drying			Per cent acid citric	Per cent reduc. sugars	AGA per cent	Per cent (N × 5.8) in		Per cent ash in solids	Per cent K in ash	Per cent citrates in	
	Total	Soluble	Water insol.				solids	conc.			solids	conc.
Early-season orange pack												
1	43.64	42.85	0.63	2.97	15.41	0.08	2.18	0.95	3.25	47.7	4.45	1.91
2	41.28	40.68	0.61	3.37	13.90	0.12	3.44	1.45	3.50	46.8	5.16	2.10
5	41.00	40.09	0.76	3.06	16.03	0.17	3.85	1.59	3.82	44.9	5.64	2.26
14	41.37	40.64	0.93	3.17	16.52	0.15	3.85	1.60	3.55	46.0	5.12	2.08
15	41.30	40.20	1.04	3.27	16.40	0.19	3.75	1.56	4.07	44.2	5.64	2.27
20	41.18	40.47	0.81	3.30	15.93	0.14	4.08	1.70	4.30	43.8	5.93	2.40
21	41.20	40.53	0.74	3.22	16.20	0.15	3.60	1.49	3.93	46.2	5.70	2.31
29	41.84	40.80	0.79	3.15	16.73	0.10	4.55	1.88	3.94	45.1	5.60	2.28
32	41.24	40.08	0.91	3.27	14.44	0.08	3.61	1.49	4.14	46.9	6.18	2.46
8	59.68	55.80[a]	....	4.53	22.93	....	3.24	1.92	3.54	45.7	4.96	2.77
26	56.97	55.77	1.06	5.19	21.22	0.20	3.49	1.99	3.86	47.9	5.81	3.24
30	56.95	55.96	0.73	4.66	21.46	0.20	3.32	1.90	4.25	44.9	5.99	3.35
		Averages					3.58		3.85	45.8	5.51	
Mid-season orange pack												
3	41.16	40.50	0.61	3.10	14.45	0.15	4.05	1.69	3.85	47.2	5.70	2.31
6	41.39	40.73	0.78	3.15	16.70	0.18	3.76	1.56	3.73	45.1	5.27	2.15
16	41.14	40.14	1.05	3.15	16.25	0.22	3.88	1.61	3.80	44.8	5.36	2.15
17	40.98	40.26	0.88	3.23	15.82	0.18	4.19	1.74	4.10	47.9	6.14	2.47
22	41.19	40.70	0.86	2.98	16.85	0.21	3.66	1.52	3.83	46.3	5.55	2.26
23	41.47	40.42	0.64	3.23	16.09	0.13	3.86	1.60	3.83	47.3	5.71	2.31
9	57.27	55.90	1.22	3.66	21.90	0.22	4.07	2.34	3.87	43.3	5.26	2.94
10	57.17	56.04	1.34	3.96	19.69	0.25	3.98	2.28	3.68	44.8	5.19	2.91
11	43.94	43.29	0.87	3.49	16.43	0.14	4.29	1.90	3.92	43.9	5.40	2.34
27	56.97	56.25	0.85	5.07	20.68	0.18	4.63	2.65	3.94	46.8	5.80	3.26
		Averages					4.04		3.86	45.7	5.54	
Late-season orange pack												
4	40.87	40.63	0.68	2.93	16.31	0.13	3.88	1.61	3.76	48.9	5.76	2.34
7	41.22	40.65	0.66	3.03	15.96	0.16	4.77	1.97	3.70	46.1	5.36	2.18
18	41.32	40.60	0.85	3.37	15.52	0.18	4.44	1.85	4.00	43.8	5.52	2.24
19	41.10	40.18	0.89	2.93	16.54	0.17	4.20	1.75	4.10	44.0	5.67	2.28
24	41.28	40.83	0.68	3.10	16.73	0.16	4.08	1.69	3.91	46.2	5.68	2.32
25	41.36	40.84	0.71	2.83	16.50	0.16	4.72	1.97	4.11	46.3	5.98	2.44
33	40.82	39.78	0.90	3.04	14.74	0.10	4.52	1.85	4.18	45.8	6.01	2.39
12	57.16	56.14	1.15	4.06	22.70	0.23	4.40	2.52	3.89	47.0	5.75	3.23
13	53.00	51.63	1.01	3.83	20.61	0.20	4.59	2.46	3.87	46.3	5.63	2.91
28	57.36	56.47	0.84	3.81	22.69	0.19	4.63	2.67	3.89	45.5	5.53	3.12
31	58.28	57.55	0.94	3.70	22.71	0.21	4.55	2.67	4.11	44.3	5.71	3.29
		Averages					4.43		3.96	45.8	5.70	
CB	58.42			6.69	24.29		3.90	2.29	2.82	44.9	4.95	2.91
CV	56.84			5.24	22.50		6.73	3.86	3.14	44.6	5.45	3.13
Tangerine and grapefruit packs												
UT-1	41.50	42.44[a]	....	3.27	14.89	....	3.87	1.64	3.82	45.9	5.51	2.29
UT-2	41.51	40.57	0.76	3.12	13.88	0.06	3.95	1.66	4.04	44.1	5.59	2.28
ST-1	41.42	40.54	0.63	3.17	14.01	0.10	3.59	1.51	3.39	41.1	4.38	1.78
ST-2	42.15	41.74	0.48	3.11	12.47	0.10	3.59	1.53	3.26	43.0	4.39	1.83
UG-1	40.20	40.24	0.27	4.59	19.99	0.09	4.58	1.86	3.47	42.6	4.98	2.00
UG-2	40.15	40.29	0.21	4.32	20.49	0.05	3.28	1.32	....	....	....	....
UG-3	38.66	38.72	0.32	4.30	17.53	0.05	4.82	1.88	4.18	46.8	6.16	2.39
UG-4	58.90	59.01	0.43	8.28	26.42	0.14	4.52	2.67	3.52	47.2	5.23	3.09
UG-5	38.80	38.23	0.35	4.73	18.36	0.08	4.68	1.82	3.31	48.2	5.01	1.92
UG-6	41.98	42.36[a]	....	4.90	21.00	....	3.61	1.53	3.39	46.0	4.90	2.06
		UG-Average					4.25		3.45	46.2	5.26	
SG-1	38.14	37.99	0.29	4.03	17.50	0.07	4.76	1.84	3.30	42.7	4.44	1.69
SG-2	40.86	40.85	0.29	3.79	16.23	0.09	3.94	1.62	4.34	43.4	5.90	2.41
SG-3	42.58	42.44	0.28	3.92	15.76	0.10	4.02	1.73	3.36	47.2	4.98	2.11
SG-4	43.30	43.73[a]	....	4.36	14.65	....	3.38	1.48	3.29	45.7	4.75	2.06
		SG-Average					4.03		3.59	44.8	5.02	

[a] Uncorrected refractometer values.

sures, finishing procedures, and suspended solids content, but there was still more than 100% variation in this component among the 4-fold orange concentrates. Grapefruit concentrates generally contained less pectin than the orange.

Results of analyses for amino compounds and citrates are presented in percentages of soluble solids as well as in percentages of the concentrates to facilitate comparison with other reports in the literature. In percentages of dry substance, amino compounds in Florida orange concentrates showed a minimum of 2.18%, a maximum of 4.77%, with an average of 4.00%. The California Valencia contained a considerably higher percentage of amino compounds than any of the Florida concentrates.

Results of analyses for ash, not being used directly in the calculation of corrections, are presented only as percentage of soluble solids. Ash content of orange concentrates varied from 3.25% to 4.30% of the soluble solids, averaging 3.89%. The ash of grapefruit concentrates was more variable than that of orange concentrates, and was generally lower.

Analyses for percentage of potassium in the ash of concentrated orange juice showed a variation between 43.3% and 48.9%, with an average of 45.8%. Potassium in the ash of concentrated grapefruit juice averaged a little higher. Mineral citrates in concentrated orange juice, calculated from potassium content, varied from 4.45% to 6.14%, with an average of 5.58% of soluble solids. In grapefruit, mineral citrates showed similar variations but with a slightly lower average.

Refractometer Corrections. In Table 3 corrections for individual components and total corrections are shown for each concentrate. Corrections were derived for glucose and fructose for 36 of the samples by treating their sums as all invert sugar. Differences between percentages of glucose and fructose were less than 1 in these samples. Samples that contained an excess of more than 1% of either reducing sugar were numbers 2, 3, 27, 31, 32, 33, ST-2, UG-1, and UG-2. The correction for each of these 9 samples was derived by using a correction for invert sugar for that part of the reducing sugars in equal concentration plus a correction for the excess of the individual sugar. Such treatment for the other 36 samples would result in corrections differing by less than 0.01% solids from those derived by treating the sum of reducing sugars as all invert.

Negative corrections for pectin and amino compounds in many instances exceeded the positive corrections for citric acid, whereas negative corrections for mineral citrates in most instances exceeded the positive corrections for reducing sugars.

Table 3. Refractometer sugar scale corrections for nonsucrose components of concentrated orange juices.

Sample no.	Refrac. value	Corrections: Acid (+)	Reduc. sugars (+)	Pectin (−)	Amino comps. (−)	Citrates (−)	Pulp (−)	Flavonoids (−)	Total (−)	Corr. refrac. value	Sol. solids[a]	Diff.
Early-season orange pack												
1	43.69	.350	.193	.200	.250	.232	.109	.120	.368	43.32	42.85	.47
2	41.73	.397	.175	.307	.385	.242	.105	.120	.587	41.14	40.68	.46
5	41.36	.360	.201	.455	.422	.254	.156	.120	.846	40.51	40.09	.43
14	41.50	.374	.208	.389	.425	.240	.225	.120	.817	40.68	40.64	.04
15	41.60	.385	.206	.500	.414	.255	.260	.120	.958	40.64	40.20	.44
20	41.69	.389	.199	.378	.452	.263	.176	.120	.801	40.89	40.47	.42
21	41.49	.379	.203	.403	.395	.256	.148	.120	.740	40.75	40.53	.22
29	41.41	.370	.210	.258	.500	.251	.163	.120	.756	40.70	40.80	−.10
32	41.25	.385	.180	.200	.395	.266	.217	.120	.633	40.62	40.08	.54
8	55.80	.535	.295	....	.510	.294	....	.120				
26	57.02	.615	.272	.532	.530	.320	.278	.120	.893	56.13	55.77	.36
30	57.28	.550	.274	.537	.505	.328	.143	.120	.809	56.47	55.96	.51
Mid-season orange pack												
3	41.79	.365	.182	.385	.449	.258	.102	.120	.767	41.02	40.60	.42
6	41.57	.370	.210	.462	.414	.245	.160	.120	.821	40.75	40.73	.02
16	41.47	.370	.204	.272	.427	.245	.376	.120	.866	40.60	40.13	.47
17	41.41	.380	.198	.460	.462	.269	.198	.120	.931	40.48	40.26	.22
22	41.55	.350	.212	.550	.403	.252	.195	.120	.958	40.59	40.70	−.11
23	42.03	.380	.202	.343	.425	.256	.113	.120	.675	41.35	41.42	−.07
9	57.42	.432	.280	.580	.622	.300	.362	.120	1.272	56.15	55.90	.25
10	57.29	.467	.250	.675	.607	.296	.425	.120	1.406	55.88	56.04	−.16
11	44.26	.410	.206	.378	.505	.258	.198	.120	.843	43.42	43.29	.12
27	57.17	.600	.265	.480	.705	.320	.188	.120	.948	56.22	56.25	−.03
Late-season orange pack												
4	41.40	.347	.205	.350	.427	.259	.125	.120	.729	40.67	40.63	.04
7	41.39	.355	.199	.420	.523	.246	.117	.120	.872	40.52	40.65	−.13
18	41.68	.397	.194	.480	.492	.251	.187	.120	.939	40.74	40.60	.14
19	41.69	.344	.208	.445	.465	.256	.208	.120	.942	40.75	40.18	.57
24	41.52	.365	.210	.418	.449	.255	.127	.120	.794	40.73	40.83	−.10
25	41.77	.331	.208	.408	.523	.265	.137	.120	.914	40.86	40.84	.02
33	41.02	.357	.186	.258	.492	.264	.210	.120	.801	40.22	39.78	.44
12	57.32	.480	.292	.612	.670	.320	.325	.120	1.275	56.05	56.14	−.09
13	53.49	.452	.263	.530	.655	.297	.256	.120	1.143	52.35	51.63	.72
28	57.77	.450	.292	.510	.710	.310	.187	.120	1.095	56.68	56.47	.21
31	58.68	.437	.292	.560	.710	.322	.227	.120	1.210	57.47	57.55	−.08
Tangerine and grapefruit packs												
UT-1	42.44	.385	.173	....	.435	.255	....	.120	....	....	....	....
UT-2	42.02	.365	.173	.166	.440	.255	.150	.120	.593	41.43	40.57	.86
ST-1	41.93	.375	.174	.260	.400	.216	.110	.120	.577	41.37	40.54	.83
ST-2	42.55	.365	.155	.271	.405	.218	.069	.120	.563	41.99	41.74	.25
UG-1	40.56	.543	.223	.248	.495	.230	.033	.120	.360	40.20	40.24	−.04
UG-2	40.20	.510	.187	.130	.350	.196	.024	.120	.123	40.08	40.29	−.21
UG-3	38.91	.508	.221	.135	.500	.258	.041	.120	.325	38.59	38.72	−.13
UG-4	59.12	.992	.328	.360	.710	.301	.061	.120	.232	58.89	59.01	−.12
UG-5	38.96	.560	.232	.205	.484	.225	.045	.120	.287	38.67	38.23	.44
SG-1	38.56	.473	.220	.185	.489	.206	.035	.120	.342	38.22	37.99	.23
SG-2	41.19	.447	.203	.242	.430	.207	.035	.120	.384	40.81	40.85	−.04
SG-3	43.07	.463	.197	.260	.460	.240	.034	.120	.454	42.62	42.44	.18

[a] By vacuum drying.

Negative corrections for pulp are smaller than any of the other corrections based on analyses of individual samples, except for 9 samples of orange concentrate, high in pulp content, that have smaller positive corrections for reducing sugars.

The uniform negative correction for flavonoids applied to all samples is based on the limited solubility of hesperidin and naringin. Derivation of the correction is described in the first paper of this series.

Variations in the size of corrections for individual components of 4-fold concentrates were greatest for pectin, showing a spread of 0.35 (−0.200 to −0.550), and were least for mineral citrates and reducing sugars, which showed respective spreads of 0.03 and 0.04. Variations for acid, amino compounds, and pulp were intermediate, showing respective spreads of 0.07, 0.13, and 0.27.

The sum of corrections for every sample is negative. Among the 4-fold orange concentrates, corrections ranged from a low of −0.368 to −0.958. It is worthy of note that total correction was lowest for sample No. 1, which analyzed lowest in acid, pectin, soluble nitrogen, and ash, and highest in sucrose. Corrections for high-density concentrates ranged from −0.809 to −1.406. Corrections for grapefruit concentrates were comparatively small, ranging from −0.123 to −0.454.

The refractometer sugar scale values are shown as read and as corrected, as well as the soluble solids as determined by vacuum drying. If the analyses for each component of each sample were accurate; if the analyses for the soluble solids and the refractometer values for each sample were accurate; and if all components of significant effect were included; the corrected refractometer values should agree quite closely with the soluble solids in each instance. While the differences between soluble solids and corrected refractometer values for individual samples look large, the average difference for orange concentrates of 0.21% is a much closer approximation than the average difference of 1.77% between soluble solids and refractometer values corrected for acid only. For grapefruit concentrates, the difference between soluble solids and refractometer values, corrected as shown, averaged only 0.04% solids, compared to an average of 0.91% for the difference between soluble solids and refractometer values corrected for acid only.

For comparisons of the accuracy and precision of multiple corrections with the accuracy and precision of uncorrected refractometer values, or values corrected only for acid to °Brix, a statistical evaluation was made of results on concentrated orange juices. Pertinent results of the analyses are shown in Table 4. The extremes of differences between soluble solids and refractometer values as estimated by each of the three methods are shown in the first line, and the mean differences in the second. These data indicate that uncorrected refractometer values were considerably more accurate (nearer to soluble-solids content) than those corrected only for acid, and that corrections for 7 components further improved accuracy. Differences in accuracy of the methods are obviously significant.

Remaining data in Table 4 indicate the relative precision of the three methods. Regression equations were calculated by the method of Snedecor (1956) to correlate soluble solids by drying with observed refractometer values, such values corrected only for acid to degrees Brix, and corrected for 7 components. Application of the regression equation to refractometer values yielded estimated soluble-solids values grouped about actual soluble solids, with about equal precision for refractometer values uncorrected and those corrected for 7 components. The values corrected only for acid showed slightly greater deviations and wider confidence limits.

It is obvious, therefore, that application of a regression equation to uncorrected refractometer values would probably achieve the same ends, increased accuracy without loss of precision, as would the application of corrections for 7 components determined experimentally. This possibility will be discussed in the third paper of this series.

Data presented here are valuable to the fruit juice processing industries because they indicate for the first time the extent of influence of some of the natural components on refractometer values, and also emphasize the complexity of the problem of determining soluble solids in natural products.

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Table 4. Statistical comparison of accuracy and precision of three methods for estimating soluble solids of concentrated orange juices from their refractometer values.

Refractometric method	Corrected for citric acid to °Brix	Uncorrected	Corrected for 7 components
Range of diffs: Refrac. — % sol. solids	1.225 to 2.605	0.603 to 1.863	−0.159 to 0.720
Mean difference: Refrac. — % sol. sols.	1.773°	1.105°	0.207
Regression equation: X = Refrac. Brix; Y = % sol. solids	Y = 0.970X − 0.400	Y = 0.984X − 0.368	Y = 1.003X − 0.342
Std. error of estimate (Std. dev. from regression)	0.275	0.259	0.259
95% confidence limits when X = 42° Brix (Precision of regression equation)	0.120	0.108	0.103
95% confidence limits for prediction when X = 42° Brix	0.574	0.539	0.539

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Proteases of Chicken Breast Muscle[a]

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SUMMARY

Protease of chicken breast muscle was separated into two fractions by column chromatography on "Selectacel" cellulose. One fraction has maximum activity at pH 4 (on hemoglobin), the other at pH 7 (on casein). Neither of these proteases is sufficiently active to account for the rapid post-rigor tenderization of chicken. It is concluded that muscle proteases probably play little part in the tenderization of meat.

THE PRESENCE of proteases in muscular tissue of various animals has been amply demonstrated, and it is often assumed that these enzymes are at least partially responsible for the tenderization occurring during aging or "ripening" of edible muscle (American Meat Institute Foundation, 1960; Whitaker, 1959). However, the pH of edible muscle varies from about 5 to 7 (Bate Smith, 1948), and muscle proteases have been reported to have pH optima in the neighborhood of 4 (Balls, 1938; Sliwinski *et al.*, 1959) and 8 (Koszal and Miller, 1960). The temperature optimum for muscle proteases appears to be 37°C (Koszal and Miller, 1960; Sliwinski *et al.*, 1959; Snoke and Neurath, 1950), although meat is usually ripened at about 4°C. The activity of these enzymes must therefore be restricted by both pH and temperature under normal ripening conditions.

Tenderization of chicken muscle occurs more rapidly (6–18 hours) (Pool *et al.*, 1959) than tenderization of beef (American Meat Institute Foundation, 1960; Husaine *et al.*, 1950). If muscle proteases play a significant role in tenderization, it would appear that protease activity should be greater in chicken than in beef. Studies on the proteases of chicken breast muscle were therefore undertaken. The results are reported herewith.

MATERIALS AND METHODS

Mature chickens were slaughtered by cutting the neck veins, bled, scalded 2 minutes at 54°C, and plucked and eviscerated by hand. The pectoralis major and minor muscles were then removed, and either extracted at once or frozen and stored at −20°C until required.

For extraction, tissue was ground in a Latapie grinder, homogenized with twice its weight of 2% potassium chloride solution in a Waring blender, and held overnight at 4°C. The supernatant extract obtained after centrifuging for 30 min at *ca* 80,000 × G (Spinco, Model L, No. 30 rotor, 30,000 rpm) was then further purified by the method of Snoke and Neurath (1950) unless otherwise stated.

For the estimation of proteolytic activity, a 3-ml portion (or less) of enzyme preparation was added to 3 ml of substrate solution at room temperature, the mixture readjusted to the desired pH, and incubated 1 or 4 hours at 37°C. An equal volume of 20% trichloroacetic acid was then added, the mixture heated for 2 min in a boiling-water bath, allowed to stand for 30 min, and filtered through Whatman No. 40 paper. Initial or "blank" samples were prepared in the same manner, except that trichloroacetic acid was added immediately following pH adjustment. A 5-ml portion of the acid filtrate was then analyzed for "tyrosine" by the method of Anson (1938). Readings, at 660 mμ, were made with an Evelyn colorimeter 10 min after addition of the Folin-Ciocalteau reagent (Fisher). Immediately after reading, the pH of the colored solution was determined, and the "tyrosine" result discarded unless the pH at this time was between 10.5 and 11.2. Careful control of pH greatly increased the reproducibility of the results. The difference in optical density between sample and "blank" was converted to "tyrosine" by reference to a standard curve.

Two substrates were used to test for enzyme activity since difficulty was encountered in keeping a single substrate in solution throughout the pH range studied. At pH 6.0 and below, 2% hemoglobin (denatured, standardized for protease assay, Nutritional Biochem. Corp.) in 0.05*M* acetate buffer, pH 4.0, was used. At higher pH levels, 2% acid casein (prepared in laboratory, dissolved by adding 1 ml of 1*N* NaOH per g casein) in 0.05*M* phosphate buffer pH 7.0 was more satisfactory.

Glass-distilled water was used in the preparation of substrates and throughout all enzyme purification procedures.

EXPERIMENTAL AND RESULTS

Preliminary tests with the crude enzyme preparation obtained as a supernatant solution by centrifugation of muscle homogenate indicated the presence of a protease active on hemoglobin at pH 4. However, the activity of this enzyme was too low to permit accurate determination of its characteristics without further purification. Attempts failed to purify or concentrate the enzyme by ammonium sulphate precipitation (Sliwinski *et al.*, 1959) or by the method of Winnick and Winnick (1959). The method of Snoke and Neurath (1950), however, gave reasonably satisfactory results (Table

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1), yielding two successive enzymatically active precipitates, one precipitated by ethanol (19%, pH 5.8, 8°C), the other by subsequent addition of alkali to pH 7.5. Since the ratio of activity between these two fractions, and the proportion of the total activity found in either one, varied markedly between tests, both fractions were studied.

Moving-boundary electrophoresis of these fractions indicated that the ethanol precipitate contained more of the fractions having relatively high mobility in phosphate buffer, pH 7.6, ionic strength 0.15. However, no relation could be established between the electrophoretic pattern and enzyme activity.

The enzyme present in both the ethanol and alkaline precipitates showed maximum activity at pH 4, with some evidence of a weak secondary activity at pH 7. The optimum temperature for hemoglobin hydrolysis was approx. 37°C, and the rate of hydrolysis decreased to about half of the maximum as temperature was lowered to 20°C. At lower temperatures the activity was too weak for accurate measurement. Higher temperatures of incubation sharply reduced the extent to which hydrolysis occurred, and heating the enzyme solution to 50°C for 10 min prior to incubation at 37°C destroyed about half of the activity.

With optimum pH, temperature, and substrate concentration (approx. 1% under the conditions of these tests) the rate of hydrolysis given by both fractions was essentially constant throughout the first hour of incubation (Fig. 1). The rate of hydrolysis decreased with incubation times longer than 60 min.

Calcium, zinc, and barium, in concentrations from .005 to .02*M*, had no activating effect; cysteine was not tested. Neither of the preparations showed significant esterase activity when tested on 0.1*M* benzoyl arginine ethyl ester for 1 hour at 37°C, at either pH 4 or 7.

The presence of a second pH optimum for proteolytic activity at pH 7 in both of these fractions suggested that more than one enzyme might be present. Therefore attempts were made to fractionate these preparations further by chromatography on a modified cellulose (Sliwinski *et al.*, 1959) ("Selectacel," Brown Co., Berlin, N. H.). Columns (1 × 10 in.) of this absorbent were washed with water of low carbon dioxide content, and charged with up to 20 ml of enzyme solution previously dialyzed against low CO_2 water. Phosphate buffers were then used for elution.

Most of the material placed on the column was removed by 300 ml of 0.05*M* phosphate buffer, but further material continued to elute in low concentration with up to 2 L of this buffer. Varying the pH of the buffer from 7.5 to 9.2 did not markedly improve the elution, but higher concentrations of phosphate appeared to reduce the "tailing" to some extent. The procedure finally selected was to elute 350 ml (seven 50-ml fractions) with 0.05*M* buffer, pH 7.5, and a further 500–600 ml with 3*M* buffer, pH 9.2. All eluates were dialyzed against several changes of water over a 36-hour period to remove the phosphate. Concentration of the eluates was then estimated by determining their optical density at 276 mμ (Beckman DU) and by their proteolytic activity (4-hour hydrolysis). Corrections were applied for the increase in volume that occurred during dialysis.

Both the ethanol and alkaline precipitates were fractionated in this manner, but no differences were detected, and these

Table 1. Protease Activity of Fractions of Muscle Extract.

Fraction	Nitrogen (mg/ml)	Tyrosine released[a] (μg/ml)	Specific activity
Original extract	5.32	12.4	2.3
Heated (37°C, 10 min) filtered extract	4.62	35.0	7.5
Heated extract after trichloroacetate treatment	1.98	21.0	10.6
Ethanol precipitate, dissolved in 25 ml	0.16	60.0	375.0
Alkaline precipitate dissolved in 40 ml	0.15	6.7	44.6

[a] Incubation for 1 hr at 37°C, pH 4.0, 1% hemoglobin, 1 ml enzyme preparation.

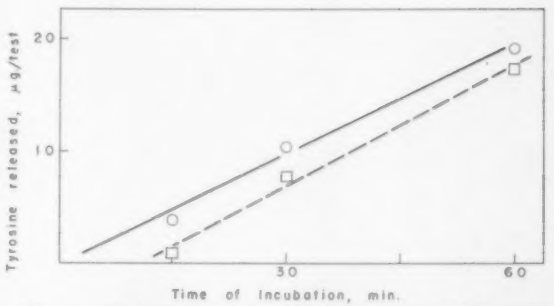

Fig. 1. Rate of tyrosine release from hemoglobin (1%) of pH 4.0 and 37° C. ○ —— fraction precipitated by ethanol (1 ml enzyme solution containing 1.06 mg total nitrogen per ml). □ ---- fraction precipitated by alkali (1 ml enzyme solution containing 0.22 mg total nitrogen per ml).

two fractions were therefore combined to give a more concentrated preparation. Typical results with this combined material are in Fig. 2. The optical density of the dialyzed eluates varied between replicate tests, indicating that elution of the slower components was unsatisfactory, and therefore no conclusion can be drawn regarding the number of components. The proteolytic activity of the eluates at pH 4 (hemoglobin) and 7 (casein) clearly indicates, however, that at least two, and probably three, proteases are present. One of these, with maximum activity at pH 7, was eluted alone in fractions 17 to 20; the others eluted together in the earlier fractions. The ratio of activity at pH 4 to activity at pH 7 varied, in different tests, from 4:1 to 25:1 in fraction 3, and from 0.3:1 to less than 0.1:1 in fraction 18. The minor peak occurring with eluate 10 appeared repeatedly, but coincided with the solvent front of 3*M* buffer, so probably indicates further elution of the poorly retained material (solvent retention volume of the column was about 80 ml).

DISCUSSION

At least two, and probably three, proteolytic enzymes are present in chicken breast muscle. One eluted slowly from "Selectacel" cellulose, and was more active at pH 7 on casein than at pH 4 on hemoglobin. The others were not separated under the

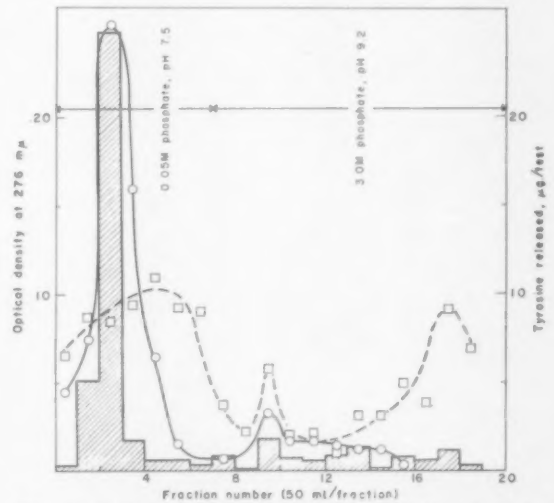

Fig. 2. Optical density and proteolytic activity of eluates. Shaded area—optical density. ○ —— tyrosine release from hemoglobin, pH 4.0. □ ---- tyrosine release from casein, pH 7.0.

conditions tested, and the mixture tended to be more active at pH 4 than 7. All of these enzymes were either present in only small amounts or were weekly proteolytic.

Proteolytic activity is normally measured by the release of amino acids or low-molecular-weight peptides, and release of particles of this size does not occur during tenderization of chicken unless the "aging" process is continued for several days (Hepburn, 1950). The only change known to occur in the protein of chicken breast muscle during a 24-hour aging period is an increase in extractability of a fraction thought to be actin (Weinberg and Rose, 1960). A tendency toward a similar increase has been reported in beef (Wierbicki *et al.*, 1954). Comparison with published results is difficult, but it appears that beef muscle is more proteolytically active than chicken muscle. (We calculate a release of about 700 μg "tyrosine" per hour per g meat from the data of Sliwinski *et al.* (1959), and of 40 μg/hr/g of chicken muscle from our own data, when tested on hemoglobin at pH 4.4 and 4.0, respectively.) Since chicken muscle tenderizes more rapidly than beef, it appears unlikely that the proteases capable of releasing "tyrosine" are predominantly responsible for the increase in tenderness of muscle during aging.

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Preparation of Locked-in Citrus Oils with "Mixed Sugars"

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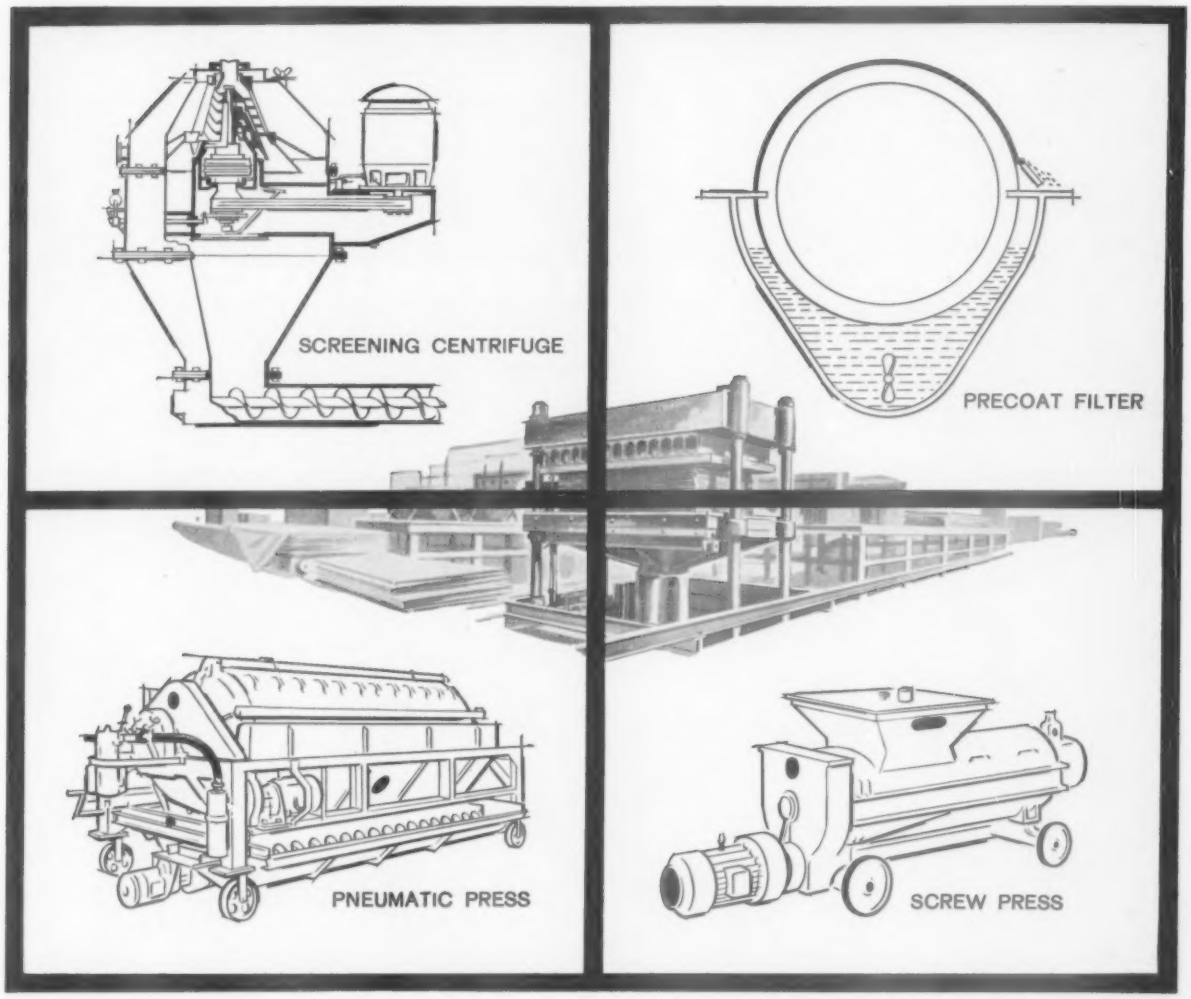
(Manuscript received October 26, 1960)

PROCEDURES DEVELOPED in this laboratory for the preparation of locked-in natural fruit flavors make use of a homogeneous mixture of sugars as the carrier for the flavoring oil (Makower and Schultz, 1959; Schultz *et al.*, 1956). The products are granular or pelleted, with the flavoring oil distributed, as minute globules, throughout the interior of each piece. In a similar method patented by Swisher (1957) the sugar mixture consists of corn sirup, corn sirup solids, or both, and antioxidants and emulsifiers are used.

Since our first report on sugars as flavor-locking agents, we have introduced a number of improvements. Use of the two original carrier compositions, anhydrous dextrose and sucrose, with minor amounts of corn sirup solids, has been discontinued for the following reasons. Products containing a high proportion of dextrose (66% or more) had a greater tendency to become sticky at normal atmospheric humidities than products having a low monosaccharide content. Although it is advantageous to store sugar-locked flavors with in-package desiccation (Talburt *et al.*, 1954) it is desirable that they be able to withstand short exposure to normal humidities without caking or becoming sticky. Moreover, it is difficult and time-consuming to melt a large batch of dextrose and corn sirup solids without appreciable decomposition. The

* A Laboratory of the Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.



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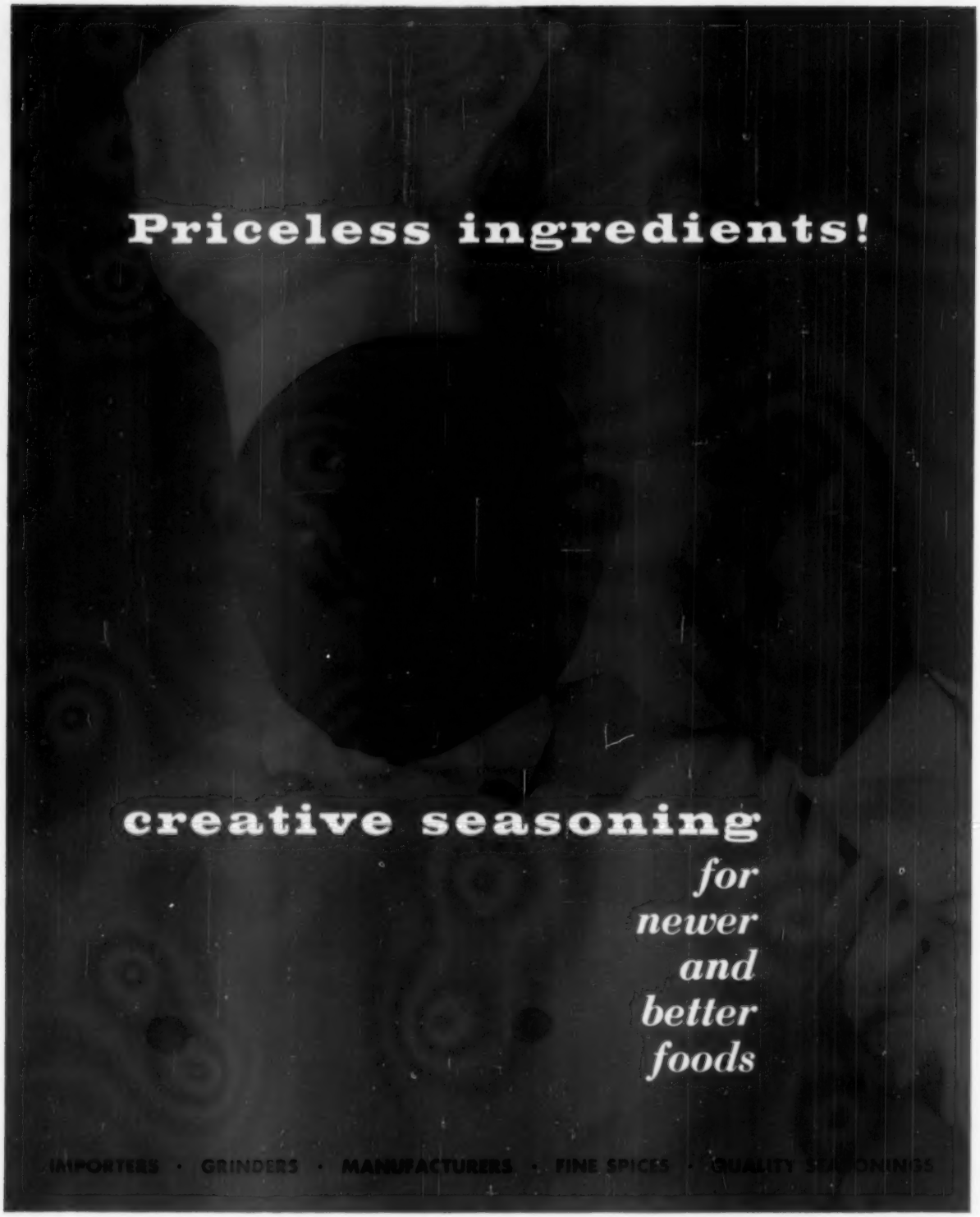

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second proposed formula consisted of 4:2:1 sucrose, corn sirup, and water, and the mixture was boiled to 150°C (sea level) to reduce moisture content to 3% or lower. This carrier behaved well in small batches but when tried with a small colloid mill designed to emulsify the flavoring oil into the carrier, the sucrose crystallized in the mill. Virtually complete crystallization also occurred on two occasions during determination of the viscosity of batches at 120°C with a Stormer viscosimeter after a few hundred revolutions. (Mention herein of various products and/or manufacturers does not imply that they are endorsed or recommended by the U. S. Department of Agriculture over others of a similar nature not mentioned.)

To overcome the difficulties noted above, a series of new carrier formulas have been developed (Schultz, 1960). Trial compositions were chosen within the following guide lines: a) that a mixture of different sugars be used with none at a proportion of over about one-third of the total; b) that the monosaccharide content be relatively low; c) that the final moisture content be not over 3%; d) that the apparent viscosity at 120°C be in the range of about 100–200 poises to enable emulsification with the flavoring oil at about this temperature and quick solidification of the product after extrusion. In all trials, initial water content was 20% and excess was boiled off to 150°C, which resulted in a moisture content of about 3%. Viscosity was determined with a Stormer viscosimeter (cup diameter 1.156 in., rotating cylinder 0.75 in.) calibrated with glycerol at 25.0°C.

Table 1 shows typical compositions that fall within the above plan and have proved satisfactory. One third to nearly half of the dextrose and all of the maltose, higher sugars, and dextrin are introduced as corn sirup of the high-maltose type (product No. 1531, Corn Products Refining Company; the maltose content is 50% moisture-free basis; solids content of the sirup is about 81%). A feature of these carriers is their high disaccharide content, 67–70%. The proportion of lactose is relatively small compared to that of sucrose because lactose has a greater tendency to crystallize. Isolated maltose is not used, because of its high price.

A carrier of desired viscosity at a given temperature can be obtained by using the constant proportions of sucrose and lactose indicated and estimating the proportions of dextrose and high-maltose corn sirup to use from the data in Table 1. A small increase in proportion of corn sirup and decrease in dextrose content gives a higher viscosity.

Table 1. Composition and apparent viscosity of carriers.

Formula designation	M	N	P
Composition, %, MFB:			
Sucrose	36	36	36
Lactose	14	14	14
Dextrose	23	21	19
Maltose[a]	17	18.5	20
Higher sugars and dextrin	10	10.5	11
Viscosity at 120°C, poises	130	160	220
Viscosity at 110°C, poises	420	520	730

[a] The corn sirup used contained 50% maltose, MFB.

Emulsifying Agents

Emulsifying agents have definite advantages, but, as pointed out later, appear to have an undesirable effect. In batch-type preparation of locked-in orange oil, with grinding of the product and removal of the surface oil by evacuation, effective emulsifying agents give a considerably higher volatile oil content (Curl, 1947) and much better oil retention (Schultz and Talburt, 1960 a, b). This improvement is associated with a decrease in average size of the oil globules. With sucrose dipalmitate or refined lecithin, at a concentration of 0.2% based on weight of the carrier, products have been obtained with 85–95% (values from the 10–20-mesh fraction) of the theoretical volatile oil content of 8.6% v/w (per cent by volume of oil based on wt of the product, including moisture; this percentage is numerically equal to the concentration as ml per 100 g). (Individual manufacturers should consult the Food and Drug Administration, Washington 25, D. C., and the food and drug officials of the individual states involved, to determine if the use of any proposed additive is permissible, and, if so, what limitations are placed on its use.) Other emulsifying agents, tried under similar conditions, were less effective, even at concentrations up to 1%; mixed mono- and di-glycerides and polyoxyethylene sorbitan monostearate respectively gave only 60 and 70% volatile oil retention. Without emulsifying agent the volatile oil retention was about 50%. When less oil was used, however, so that the theoretical volatile oil content was 6.4% v/w instead of 8.6% v/w, retention was 73–80%.

A preparation made with lemon oil and lecithin showed 96% oil retention in the 10–20-mesh fraction and 94% retention in the 20–30-mesh fraction. Thus, the marked decrease in oil retention formerly associated with decreasing particle size can be avoided.

When sucrose dipalmitate is used, it is added to the mixed sugars about a minute before completion of boiling off the excess water. When lecithin is used, it is predissolved in the citrus oil.

The main disadvantage of an emulsifying agent is that the effectiveness of the product in flavoring reconstituted orange juice powder is impaired, at least under the conditions of our experiments. The effect is small, but has been observed repeatedly. The emulsifying agent does not directly impart an off-flavor. The impairment of flavor appears to be associated with a lowering of both the rate of dissolving of the oil in water and the rate of volatilization of the oil from water dispersions. More work is necessary to assess the practical importance of this type of flavor deficiency and, if possible, to find conditions under which it can be avoided while retaining the advantage of high oil retention during preparation of the product.

Procedure

Preparation of a typical 1.5-lb batch of locked-in orange oil with formula M (Table 1) was as follows. The equipment used was a stainless-steel 1200-ml 4-in.-diameter open kettle provided with a model F (1/30 H.P.) Lightnin' Mixer fitted with a 3-blade 2-in.-diameter impeller about ½ in. above the bottom of the kettle. Heat was supplied by a gas stove burner with wire

gauze. The orange oil was pumped into the carrier with a size-5 Zenith metering pump, fitted with a 1/16-in. O.D. delivery tube stabilized with a 1/4-in. rod. The whole pump assembly was arranged so that it could be lifted up and lowered into position with the tip of the delivery tube about 1/4-in. above the impeller and 3/4-in. from the axis of the shaft. (The flavoring oil could be introduced with a large hypodermic syringe or a pipette, with blowing; however, it is important that the oil be introduced at a region of high rate of shear or turbulence of the carrier.)

The following materials were used: 250 g sucrose; 100 g lactose (U.S.P.); 110 g dextrose (Cerelose 50, Corn Products Refining Co.); 300 g corn sirup, high maltose (No. 1531, Corn Prod. Ref. Co.); 115 ml water; 1.4 g sucrose dipalmitate; 71 ml orange oil (California cold pressed). With these quantities and allowance for the slight amount of nonvolatile matter in the oil, the theoretical volatile oil content of the product (at 2.5% moisture) is 9.0% v/w.

The sugars, sirup, and water were mixed in the kettle with a spatula until smooth, then heated with rapid stirring to boil off excess water. When 140°C. was reached, the rate of heating was reduced; at 148° C the sucrose dipalmitate was added; and at 150°C the burner was turned off. The time of heating to this point was 32 minutes. While the mixed sugars cooled, the mixer was turned to its slowest speed sc as to beat in as little air as possible. When 132°C was reached the pump assembly, with prefilled delivery tube, was lowered into position, the stirrer was turned to full speed (1600 rpm), and the orange oil at 25°C was pumped in over a period of 3.7 minutes. Stirring was continued two minutes and the emulsion was poured onto a stainless-steel sheet to a thickness of 1/8–1/4 in. The slab was allowed to cool 2 hours in a low-humidity room (15% R.H. or lower), ground with a coffee mill set for a coarse grind, and screened with 10- and 20-mesh sieves. The material coarser than 10 mesh was repeatedly reground, with progressively finer mill settings and screening after each pass. The accumulated 10–20-mesh fraction was evacuated 22 hours at 0.001 mm of mercury and washed with iso-propyl alcohol to remove surface oil, evacuated again to remove solvent, and bottled with a 10-g envelope of desiccant. The yield of 10–20-mesh product was 70% of the weight of total ground material, including fines. (The yield can be increased to about 80% by retaining the 10–30-mesh fraction.) The volatile oil content of the product was 7.8% v/w, and the moisture content (Fischer) was 2.5%. Only 0.83 g of the product is required to flavor 1 qt of reconstituted orange juice to the 0.0065% v/w level of added oil, or 1.28 g for the 0.010% v/w level.

Flavor Stability

Samples of the locked-in orange oil product described, and a similar preparation made with cold-pressed lemon oil, were placed in Mason jars with a small desiccant envelope in each and with 93% head space (air). After six months in the dark at 100°F the flavor was rated by eleven experienced judges, with the same preparations kept at −20°F as controls. The media for the tests were otherwise unflavored, reconstituted California orange juice and lemonade, respectively, prepared from products that had been stored cold. No difference was found between the stored locked-in flavor and the control, with either orange or lemon. These results, in agreement with earlier findings, indicate very good stability of citrus oils locked in "mixed sugars."

Practical Considerations

Although we have not adapted the process described above to commercial scale, it appears that this could be done in several different ways. Continuous emulsification of the flavoring oil with the carrier in a closed mixer with short retention time, followed by extrusion to particles of the desired size, appears to be the best system for ultimate development. Such a process should practically eliminate loss of flavoring agent by avoiding surface oil and fines. Our work along this line, which has been briefly described (Schultz, 1958; Schultz *et al.*, 1958), has not proceeded to the point that we can give a more detailed report on it.

With batch-type operation, we have made two 40-lb preparations of locked-in orange oil with fair success. The procedure was basically the same as that described above for 1.5-lb batches, with larger equipment, including a steam-jacketed kettle. The orange oil was introduced through ten small holes near the end of the delivery tube. Further expansion of this completely batch-type operation would appear to be difficult and cumbersome.

A more feasible plan is a proposed semi-continuous process in which the "mixed sugars" carrier is prepared in a large batch and held hot, while pumping it in one pass through a mixer and directly onto trays or a cooling drum. The flavoring oil would be introduced by a small metering pump into the carrier in the mixer at a region of high rate of shear or turbulence. Such a plan appears to be the most attractive approach to commercial-scale operation, short of the completely continuous plan with extrusion to small pellets.

Acknowledgment

The authors thank Melvin Lazar and George Smith for assistance in preparing the 40-lb batches of locked-in orange oil and for suggestions on expansion of the process to commercial scale. We thank W. C. Rockwell for design of the colloid mill, and Doris Taylor for assistance with the flavor tests. The interest and counsel of C. C. Nimmo is gratefully acknowledged.

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Studies on the Evaluation of Freshness and on the Estimation of the Storage Life of Raw Fishery Products*

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SUMMARY

Determinations of the contents of volatile reducing substances (VRS) and trimethylamine nitrogen (TMN), and of the percentage of pigmented bacteria before and after 5 hours of incubation at 31°C (88°F) are suggested as useful criteria for evaluating the freshness of raw fish samples and estimating the keeping quality at refrigerated storage temperatures above freezing. Applications to flatfish and rockfish fillets, salmon steaks, tuna, and unpeeled beheaded shrimp are given for both experimentally stored and commercial samples.

THE WIDE VARIETY of methods available for evaluating the freshness of fish and shellfish can be regarded as being predominantly, if not entirely, spoilage detection procedures. The deteriorative processes leading to detectable spoilage are continuous and progressive from the time the organisms are removed from their environment and die. Nevertheless, available procedures for evaluating the condition of fish and shellfish usually yield fairly constant, or at best slowly increasing, values during the early stages of the deteriorative processes before any definite chemical changes become detectable. That changes are occurring during this early post-mortem period is evident from sensorily detectable differences, such as decrease of the bland, mild, "seaweedy" or seawater odor to a state where no odor is detectable. As a result, it is ordinarily very difficult to evaluate freshness accurately, and even more so to obtain a reasonably accurate forecast of its storage life.

The common fish and shellfish spoilage pattern is primarily the result of bacterial action. We therefore considered the possibility of accelerating this bacterial action by the microorganisms that may be present on the sample to such a degree that we could obtain a reasonably correct indication of the closeness of the sample to the end of the fresh period and at the same time arrive at some estimate of its storage potential. The possibility of accelerating the action of the bacteria by incubating the sample, and thus to obtain a measure of the initial contamination and the state of freshness, has been discussed by a few investigators. Hess (1941) published some preliminary data to show that determination of the trimethylamine content before and after a 3-hour incubation at 25°C (77°F) gave a better indication of the freshness of a sample as well as of its keeping quality at a lower storage temperature of 0.5°C (33°F) than the amine content in the original sample. If trimethylamine content did not increase during the incubation period it could be concluded that the sample was in the early stages of the initial freshness period and that it would likely keep for several days at the storage temperature. If amine increase was appreciable during incubation it could be concluded that the sample was near the end of its freshness period and would not keep long in storage. Tarr (1943) reported that direct counts on fish samples with a low bacterial contamination could be made more significant by incubating the sample 24 hours at 15°C (59°F) and making a direct count of bacteria numbers. He found no relation between the bacterial counts obtained before and after incubation. He suggested, however, that the increase in numbers of bacteria found after the incubation period was related to the potential keeping quality of the original sample. Finally, Vaisey (1956) presented data suggesting that tyrosine values before and after a 3-hour incubation at room temperature could be used to separate cod fillets into fresh and spoilage groups. Furthermore, the presence of nitrite did not inhibit the increase in the tyrosine values, as it did that of trimethylamine.

It may be of interest to define briefly our concept of freshness of fish and shellfish. From the moment the organism dies, which may be regarded as the point of ideal or maximum freshness, until the first definite indication or sign of spoilage that is detectable sensorily or chemically, there occurs a continuous series of changes, about which at present little is definitely known. The period between the two points of reference on the freshness scale (maximum freshness and that signaling its end or the beginning of spoilage) will depend mainly on handling conditions, including storage temperature and extent of contamination. The degree of freshness of a sample can therefore be expressed in two ways: 1) comparing the content of certain constituents, such as volatile reducing substances (VRS) or trimethylamine nitrogen (TMN), with that to be expected at the point of maximum freshness, and 2) by the duration of the time during which the sample can be kept before the first signs of deterioration can be detected under the particular storage conditions. The reliability of these criteria will depend on the sensitivity of the methods available to measure the changes in the content of the constituents. Present methods are gen-

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erally insufficiently sensitive to detect significant changes during the early stages of freshness, and are still less adaptable to estimation of the remaining portion of the freshness time scale. For example, a sample of fish with a freshness storage life of three days at 5.6°C (42°F) will, after 1 and 2 days, have left only 2 days and 1 day of storage time of the freshness scale. Nevertheless, when tested chemically, such samples may show no or insignificant changes in VRS or TMN, and they may all be sensorily judged "fresh." In this report data are presented on various means of evaluating the degree of freshness of various types of fish and shellfish according to the aforementioned concept. The usefulness of the incubation technique in accelerating the spoilage pattern has been more extensively studied, and an approach has been made toward a differential analysis of the significance of the bacterial flora associated with fish of varying degrees of freshness throughout the freshness scale.

No data are generally available in the literature directly correlating the content of pigmented bacteria with the state of freshness of raw fish. There are, however, some indications of the decrease in percentage of pigmented bacteria during storage. Reay and Shewan (1949) reviewed the bacteriology of fish spoilage and referred to unpublished as well as published data showing some decreases in the percentage of the Micrococcus and Flavobacter genera during storage of haddock, codling, salmon, and herring in ice or at other temperatures. They stated that "the percentage distribution, however, alters markedly during spoilage, the Achromobacter and the Flavobacter or Pseudomonas increasing relatively at the expense of the Micrococci." Wood (1952) reported that pigmented forms of micrococci were found chiefly on or in fish, that they were normal inhabitants of the slime of teleost fish, and that they were found "in the early stages of teleost spoilage." In another paper (1953) Wood reported that on fish the pigmented cocci represented about 50% of the cultures, and that Pseudomonas was abundant in fish only in the later stages of spoilage. He stated that "with teleost fish, a succession of genera was observed during spoilage, and this was also found in crayfish spoilage."

During our work on the spoilage of fish it was observed that fresh samples, particularly fillets of sole or of rockfish, had a relative predominance of pigmented micrococci and smaller amounts of flavobacteria, and that during the early stages of storage, even before definite spoilage became evident, the percentage of the pigmented bacteria markedly decreased, whereas the percentage of the non-pigmented Gram-negative rods, mainly Pseudomonas, increased and became dominant as spoilage set in. Studies on the ecology of the pigmented bacteria, and their spoilage potential, are in progress; data on the differential bacteriology of fresh fish and the changes during early spoilage will be presented in subsequent reports.

MATERIALS AND METHODS

Fish and shellfish. For the storage experiments the sole [various types of flatfish, including Dover (Microstomus pacificus), English (Parophrys vetulus) and Petrale Sole (Eopsetta jordani)], rockfish (various members of the Sebastodes genus), and salmon (King or Ocean Chinook, Onchorhynchus tshawytscha) were obtained early in the morning soon after being unloaded. The fish were ordinarily hours out of the water when landed. The sole and rockfish were filleted in the processing plants; the dressed salmon were cut into steaks about ¾ inches thick in the laboratory. The tuna was a frozen albacore (Thunnus germo) obtained from a local cannery soon after unloading from the fishing vessel. The albacore was thawed sufficiently to allow cutting it into a number of cross-sectional pieces, which were then stored. The shrimp were raw unpeeled beheaded white shrimp (*Pandalus* sp.) caught in Mexican waters off Baja California and frozen in 5-lb blocks. The block was sufficiently defrosted at room temperature to allow separation of the shrimp. The commercial samples were obtained from the processing plants or from material purchased by the University of California for hospital diets.

Spoilage determination methods. The state of freshness or of spoilage of the samples was evaluated by determination of the contents of VRS and TMN, total aerobic bacterial counts, and the percentage of pigmented bacteria on a press juice prepared from each sample, using non-absorbent gauze to wrap the material, an aluminum cylinder and piston as pressure chamber, and a hydraulic press designed in this laboratory. The clean pressure chamber was rinsed with very hot water before addition of the sample wrapped in gauze. The chemical procedures for determination of VRS and TMN have been described (Farber and Ferro, 1956). The total aerobic bacterial counts were made on suitable saline dilutions of the press juice. A 0.01-ml portion of three serial tenfold dilutions was spread on the marked-off surface of a Petri plate containing Difco Bacto Penassay Base Agar and incubated 48 hours at ambient temperature (80°F (26.7°C)–90°F (32.2°C). Duplicate plates containing three dilutions were usually made for each press juice, and the average of the two determinations for each dilution was used. The pigmented bacterial colonies were counted on each plate, and expressed as a percentage of the total number. An estimate of the presence of pigmented and other bacteria in a sample was obtained by the following technique. A clean glass microscope slide was lightly scraped across the surface of the fish sample, and the smear was spread evenly by the edge of another clean glass slide. The air-dried smear was fixed with heat and Gram-stained. The stained smear was examined for the presence of Gram-positive cocci and of Gram-negative rods. Each sample (before and after incubation) was also examined sensorily, and its acceptability was evaluated by three laboratory personnel familiar with the products under study. All the storage experiments were carried out at 42°F (5.6°C) in a household type of refrigerator, except that on tuna, which was stored in a metal shed at an average of 65°F (18.3°C). The incubation tests were carried out at 88°F (31°C) on half of the samples removed after progressive storage periods or of the commercial samples submitted to the laboratory.

RESULTS

The results of a storage experiment on sole fillets are shown in Table 1. The lack of an appreciable increase in the chemical criteria after incubation of a really fresh sample is clearly seen, in contrast to the marked increase in chemical values after incubation of samples of varying degrees of freshness approaching the spoilage state. The VRS values after 1 and 2 days of storage were still in the range for acceptable fillets, whereas after a 5-hour incubation period they were in the range of spoiled fillets (above 15 microequivalents per 5 ml of press juice). The same was found for the TMN values. The decrease in the percentage of pigmented bacteria in the samples reflected the course of the storage to a greater

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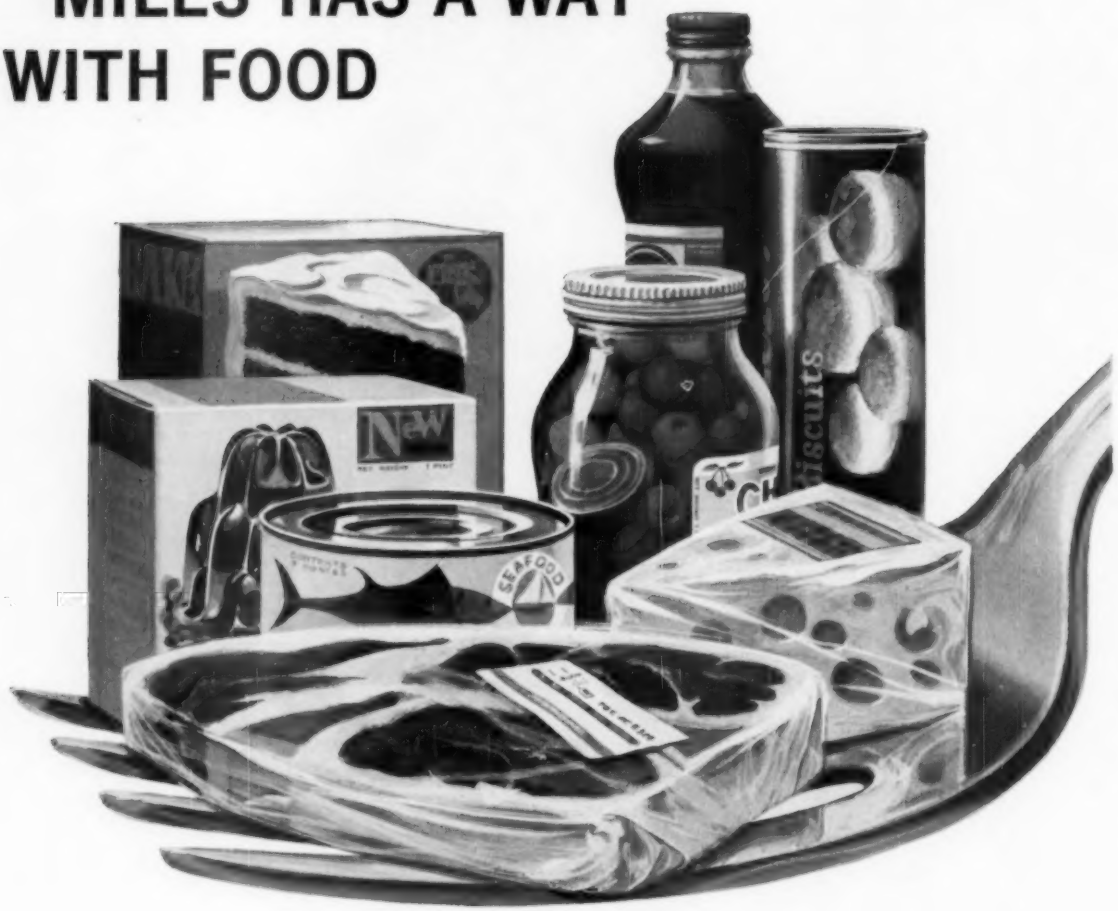

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Table 1. Content of VRS, TMN, and pigmented and total bacteria in sole fillets during storage at 42°F (5.6°C).

Days stored	Hours incubated[a]	VRS[b]	TMN[c]	Log bacteria per ml	% pigmented bacteria	Sensory judgment
0	0	1.6	0	5.75	85	Fresh—bland odor
	3	1.9	0	5.83	70	Fresh—bland odor
	5	3.0	0	6.44	35	Fresh—bland odor
	7	4.8	1.5	7.31	0	Still fresh odor
1	0	5.2	0.8	5.61	65	Fresh—bland odor
	3	9.7	3.0	6.16	16	Acceptable—stronger odor
	5	20.4	8.3	6.21	6	Spoiled
	7	27.3	9.5	7.58	0	Spoiled
2	0	5.8	2.4	5.92	15	No bland seawater odor—still acceptable
	3	7.0	6.7	6.52	0	Acceptable—somewhat stronger odor
	5	36.1	15.4	7.28	0	Spoiled
	7	40.0	18.6	7.65	0	Spoiled
3	0	30.5	13.5	6.41	0	Spoiled
	3	41.4	18.3	6.73	0	Spoiled
	5	46.6	18.1	7.26	0	Spoiled

[a] Incubation temperature was 88°F (31°C).
[b] VRS, microequivalents of volatile reducing substances per 5 ml of press juice.
[c] TMN, milligrams of trimethylamine nitrogen per 100 ml of press juice.

extent than did the chemical criteria and, in this case as well, incubation accelerated their decline. The results of a similar experiment on rockfish fillets are in Table 2. In this case the chemical values also increased after incubation while the fish were still judged to be acceptable, but the increases did not occur as early in the storage period. Here, too, the pigmented bacteria decreased during storage and to a greater extent during incubation of the samples, particularly in the later stages of the storage period approaching the end of the acceptable state.

The results of a storage experiment on a fatty fish, salmon, are shown in Table 3. In this case the results were complicated by the onset of fat rancidification processes associated with color bleaching, before manifestation of any of the changes usually associated with bacterial spoilage, with production of the characteristic off-odors. Only in the late stages of the storage period were characteristic spoilage odors detectable. The chemical criteria reflected the change in the spoilage pattern. The trimethylamine values increased only during the late stages of the storage period, as did the VRS values. In the intermediate storage time, incubation increased the VRS values, whereas later the incubation resulted in a decrease in the VRS values. Failure of the VRS values to reflect the presence of some types of rancidity was observed previously. The amount of pigmented bacteria decreased during storage, with a decrease also occurring during incubation.

The results of storage experiments on thawed frozen albacore tuna at two temperatures are presented in Table 4. Tuna is also a fatty fish, similar to salmon, and with a tendency to exhibit rancidification changes, particularly at lower storage temperatures. Incubation of the samples produced no increases in the chemical criteria, but resulted in an increase in total bacterial numbers and, more significantly, changes in the percentages of the pigmented bacteria. Days before any significant increase in VRS and before definite spoilage was evident, the percentage of pigmented bacteria had dropped to a low level, and the decrease was generally accentuated by incubation. During early storage, when the fish samples were still judged fresh, the pigmented bacteria showed no decrease, or even increased somewhat. Further experiments will show the validity and significance of these changes in the proportion of pigmented bacteria.

Data from a storage experiment on unpeeled raw beheaded shrimp are presented in Table 5. It can be seen that an incubation during the early stages of the storage period results in no significant increase in chemical criteria, whereas during the later stages, even when the shrimp are still judged to be acceptable, it produces a marked increase in the chemical criteria. Increases in bacterial content also occurred, but these were not so marked. Since the shrimp experiments were carried out prior to realization of the importance of the pigmented bacteria, no differentiation was made between types of bacteria. In later studies on the bacterial population, this aspect will be investigated as well.

The data of Tables 1 to 5 were all from experiments on the storage of originally fresh material that was allowed to spoil. As a further and more practical test of the significance

Table 2. Content of VRS, TMN, and total and pigmented bacteria in rockfish fillets during storage at 42°F (5.6°C).

Days stored	Hours incubated[a]	VRS[b]	TMN[c]	Log bacterial numbers/ml	% pigmented bacteria	Sensory judgment
0	0	2.8	0	5.74	20	Fresh
	3	2.8	0	5.73	25	Fresh
	4	2.8	0	5.60	17	Fresh
	5	3.3	0	5.61	14.5	Fresh
1	0	3.3	0	5.18	25	Fresh
	3	3.3	0	5.43	26	Fresh
	4	2.8	0	5.50	18	Fresh
	5	3.3	0	5.38	16.5	Fresh
2	0	4.3	0	5.62	16.5	Fresh
	3	3.9	0	5.79	33	Fresh
	4	5.6	0	5.96	23	Fresh
	5	6.1	1.0	6.42	5.4	Not as mild an odor, still fresh
3	0	3.3	0	5.75	18	Fresh
	3	5.6	0.5	6.69	8	Fresh
	4	7.0	1.0	6.85	0	Still fresh, sl. stronger odor
	5	8.9	2.2	6.91	0	Still fresh, sl. stronger odor
4	0	11.2	0	6.36	4.3	Still acceptable—not very fresh
	4	19.6	3.3	6.45	0	Spoiled
	5	18.4	3.2	6.75	0	Spoiled
5	0	11.3	4.8	7.0	0	Still acceptable—not very fresh
	4	19.0	7.5	7.25	0	Spoiled
6	0	19.6	7.5	7.93	0	Spoiled

[a] Incubation temperature was 88°F (31°C).
[b] VRS, microequivalents of volatile reducing substances per 5 ml of press juice.
[c] TMN, milligrams of trimethylamine nitrogen per 100 ml of press juice.

Table 3. Changes in salmon steaks during storage at 42°F (5.6°C).

Days stored	Hours incubated[a]	VRS[b]	TMN[c]	Log bacterial numbers/ml	% pigmented bacteria	Sensory judgment
0	0	7.8	0	5.23	94	Good—fresh
	3	6.7	0	5.16	72	Good—fresh
	4	7.8	0	5.32	33	Good—fresh
	5	8.9	0	5.35	21	Good—fresh
1	0	6.1	0	5.83	15	Good—fresh
	3	6.1	0	5.90	30	Good—fresh
	4	5.6	0	5.90	25	Good—fresh
	5	6.1	0	6.08	46	Good—fresh
2	0	4.4	0	5.56	30	Good—fresh
	3	7.8	0	6.00	50	Good—fresh
	4	6.7	0	5.73	11	Good—fresh
	5	6.1	0	6.18	6.5	Good—fresh
3	0	7.2	0	6.04	45	Signs of rancidity on belly portions
	3	7.2	0	6.43	22	Signs of rancidity on belly portions
	4	14.0	0	5.12	41	Definite strong odor—questionable acceptability
	5	24.0	0	6.08	0	Spoiled
4	0	7.2	0.5	7.08	0	Some rancidity & bleaching of color
	3	21.8	2.1	7.08	0	Increased during incubation
	4	23.5	3.2	6.83	0	
	5	23.5	3.4	7.12	0	
5	0	12.8	2.7	8.10	0	Sour & rancid odors
	3	10.0	2.7	8.38	0	Decreased during incubation
	4	9.1	2.5	8.45	0	
	5	7.8	2.1	8.40	0	
6	0	30.8	8.1			Sour and spoiled odors
	3	15.6	5.4			Decreased during incubation
	5	14.0	3.3			

[a] Incubation temperature was 88°F (31°C).
[b] VRS, microequivalents of volatile reducing substances per 5 ml of press juice.
[c] TMN, milligrams of trimethylamine nitrogen per 100 ml of press juice .

Table 4. Changes in albacore tuna at two storage temperatures—42°F(5.6°C) and 65°F(18.3°C).

Days stored	Hours incubated[a]	VRS[b]		TMN[c]		Log bacterial numbers/ml		% pigmented bacteria		Sensory judgments	
		42	65	42	65	42	65	42	65	42	65
0	0	6.4		0		4.04		27		Fresh	
	5	8.1		1.6		4.86		50		Fresh	
1	0	8.1	7.5	2.2	2.2	5.63	4.73	50	15	Fresh	Fresh
	5	10.8	9.7	0	2.7	5.32	6.26	28	0	Fresh	Fresh
1.5	0	....	9.7	....	2.7	....	6.12	....	7.5	....	Fresh
	5	....	9.7	....	0	....	7.00	....	10		Fresh
2	0	11.8	14.0	2.7	4.3	5.91	8.04	86	0	Still acceptable	Somewhat strong—borderline
	5	9.7	11.8	0	0	6.42	8.15	7.5	0	Still acceptable	Somewhat strong—borderline
2.5	0	....	25.3	....	0	....	8.12	....	0	....	Spoiled
	5	....	27.0	....	0	....	8.40	....	0		Spoiled
3.5	0	....	34.5	....	0	....	8.60	....	0	....	Putrid
5	0	11.3	....	0	....	6.75	....	0	....	Still acceptable	
	5	10.2	....	1.6	....	7.36	....	0	....	Still acceptable	
7	0	21.6	....	2.7	....	8.00	....	0	....	Spoiled	....
	5	18.9	....	3.7	....	8.81	....	0	....	Spoiled	

[a] Incubation temperature was 88°F (31°C).
[b] VRS, microequivalents of volatile reducing substances per 5 ml of press juice.
[c] TMN, milligrams of trimethylamine nitrogen per 100 ml of press juice.

Table 5. Changes in unpeeled raw beheaded shrimp during storage at 42°F (5.6°C).

Days stored	Hours incubated[a]	VRS[b]	TMN[c]	Log bacterial numbers/ml	Sensory judgment
0	0	6.7	0	5.90	Good bland odor
	3	6.1	0	6.86	Good bland odor
	4	6.1	0	6.78	Good bland odor
	5	5.6	0	6.81	Good bland odor
1	0	6.1	0	6.51	Somewhat stronger odor—still acceptable
	3	6.1	0	6.76	Somewhat stronger odor—still acceptable
	4	6.5	0	6.97	Somewhat stronger odor—still acceptable
	5	7.2	0	7.18	Somewhat stronger odor—still acceptable
2	0	12.3	1.0	7.23	Strong odor—still acceptable
	3	13.4	2.7	7.89	Somewhat stronger—near borderline
	4	19.0	3.2	8.04	Ammoniacal—spoiled
	5	25.7	8.1	8.23	Very ammoniacal—spoiled
3	0	14.0	2.7	8.32	Very strong and ammoniacal odors—questionable
	3	24.6	9.2	8.72	Spoiled
	4	17.3	2.7	8.70	Spoiled—decreased intensity
	5	11.7	2.2	8.78	Spoiled—decreased intensity
4	0	23.5	3.2	8.65	Spoiled—very ammoniacal

[a] Incubation temperature was 88°F (31°C).
[b] VRS, microequivalents of volatile reducing substances per 5 ml of press juice.
[c] TMN, milligrams of trimethylamine nitrogen per 100 ml of press juice.

Table 6. Applications of the incubation procedure and the percentage of pigmented bacteria to evaluation of quality of commercial fish samples.

Fish sample	Hours incubated[a]	VRS[b]	TMN[c]	Log bacterial numbers/ml	% pigmented bacteria	Sensory judgment
Sole	0	5.4	0.5	5.88	26	Fresh
	5	7.5	1.0	5.78	21	Fresh
	0	3.1	0	4.99	....	Fresh
	5	3.5	0	....	....	Fresh
	0	4.1	0	5.32	58	Fresh
	5	5.7	0	5.48	20	Fresh
	0	4.1	0	6.30	....	Fresh
	5	3.5	0	....	....	Fresh
	0	4.3	0.8	5.81	61	Fresh
	5	4.3	0	5.92	65	Fresh
Rockfish	0	7.2	0	5.91	....	Fresh
	5	6.0	0	5.98	....	Fresh
	0	3.7	0	6.15	32	Fresh
	5	4.3	0	6.20	16	Fresh
	0	3.2	0	5.99	....	Fresh
	5	3.5	0	5.96	....	Fresh
	0	4.1	0	5.74	....	Fresh
	5	4.6	0	....	....	Fresh
	0	6.4	0	5.90	47.5	Fresh
	5	6.4	0	6.28	51.0	Fresh
Tom Cod	0	8.1	1.1	5.18	....	Fresh
	5	8.3	1.6	....	....	Fresh
Sole	0	3.7	0	6.30	25	Fresh
	5	6.4	1.0	7.08	1	Not quite as bland
	0	3.9	0	5.43	58	Fresh
	5	5.9	0	5.48	6.6	Still fresh—sl. less bland
	0	3.7	0	6.26	1.2	Fresh
	5	5.4	1.0	6.56	0	Still fresh—not as bland
	0	2.8	0	5.26	40	Fresh
	5	8.9	0.2	6.32	0	Not as fresh
	0	3.6	0	6.85	0	Fresh
	5	8.8	1.0	7.83	0	Acceptable, not perfectly fresh
	0	11.8	0	5.08	0	Acceptable
	5	8.1	0	5.11	0	Still acceptable
Rockfish	0	10.2	0	6.04	0	Acceptable
	5	16.2	1.6	7.95	0	Spoiled odor
	0	6.1	0	5.85	30	Fresh
	5	10.0	0.5	6.43	0	Acceptable
	0	12.4	2.7	6.85	....	Acceptable—not fresh
	5	16.1	4.0	7.65	....	Spoiled odor
	0	2.7	0	6.08	3.2	Fresh
	5	2.7	0	6.57	0	Fresh
	0	3.9	0	5.74	7.0	Fresh
	5	5.0	0	6.45	0	Fresh

[a] Incubation temperature was 88°F (31°C).
[b] VRS, microequivalents of volatile reducing substances per 5 ml of press juice.
[c] TMN, milligrams of trimethylamine nitrogen per 100 ml of press juice.

of the criteria of freshness described above, a number of commercial samples of fish from the ordinary channels of distribution, usually at the wholesale level, have been studied in a manner similar to that for the experimental ones. Since satisfactory increases were obtained after an incubation for 5 hours at 88°F (31°C), the commercial samples were all incubated under these conditions. Table 6 shows: the data obtained for a number of samples of fish that were judged to be quite fresh, in which no or insignificant increases were found in values for chemical criteria after the incubation period, and no marked decreases in the proportion of pigmented bacteria; and the data for a number of samples considered passable or acceptable but generally judged not perfectly fresh. In the latter samples it is evident that a definite change was found in some, if not all, of the criteria after incubation, compared to the state before incubation. In most cases the per cent of pigmented bacteria was less in these samples than in those of the former group, and there was some increase in the chemical criteria after incubation. Some of the samples had no pigmented bacteria at the start, even though the values for the chemical criteria were still in the passable or acceptable range. The complementary nature of the various criteria of freshness before and after incubation was also quite noticeable. The lesser significance of the total aerobic bacterial count in relation to the other criteria of freshness was also generally evident.

DISCUSSION

An examination of the data presented enables a number of observations to be made, and some tentative conclusions to be drawn. For the low-fat white-fleshed ground or bottom fish, determinations of VRS and TMN enabled reasonably accurate evaluation of the acceptability of a sample. Addition of the percentage of pigmented bacteria made possible an estimate of freshness. By making the above determinations before and after a 5-hour incubation at 31°C (88°F), a much more reliable evaluation of freshness was possible than was otherwise the case.

The data of Table 1, which are representative of a number of similar storage experiments at various temperatures, exemplify the possible usefulness of these criteria. Both the starting material and the fillets after a one-day storage at 42°F (5.6°C) had low values for VRS and TMN, high percentages of pigmented bacteria, and bland odors, and were sensorily judged fresh. Nevertheless, the starting material had about a 1-day to 1½-days longer storage life than the sample after a one-day storage. An indication of this difference, which was not readily evident from the unincubated fillets, was obtained from examination of the incubated fillets. The original starting material showed no appreciable increase in VRS or TMN or decrease in pigmented bacteria after incubation, whereas the fillets stored for one day showed a definite change after 3 hr and marked differences after 5 hr of incubation at 31°C (88°F). Similarly,

a comparison of the fillets stored 2 days with the previous samples showed still greater differences after incubation. Even after a 3-hr incubation the two-day-stored fillets no longer had any pigmented bacteria, which were also markedly reduced in amount at the start of the incubation period. The storage life of the two-day-stored fillets was only about half a day at 42°F (5.6°C), since by the third day the fillets were spoiled. It can therefore be stated with reasonable assurance that, based on the information accumulated to the present, with the criteria of VRS, TMN, and amount of pigmented bacteria before and after a 5-hr incubation at 31°C (88°F), the freshness of a sample of low-fat white-fleshed fish can be measured with quite a high degree of reliability, compared to the freshest fish at present commercially available. Furthermore, with the above criteria an estimate can also be made of the storage life under refrigerated storage conditions of a sample of the above fish. As more data are accumulated on the effect of incubation on the three criteria in fish with different histories stored under various conditions, it may become possible to predict their possible storage life with greater reliability and even to establish tables or charts of storage times at various temperatures.

Similar observations applied to the bottom fish with a somewhat higher fat content, such as the rockfishes. In the case of these fish the spoilage of the fat through rancidification processes complicated the picture and partially blocked the effect of an incubation of the sample. Nevertheless, the three criteria before and after incubation for 5 hours at 31°C (88°F) give a reasonably reliable evaluation of the freshness of a sample. This is exemplified particularly by the data of Tables 6 and 7, where commercial samples of both low-fat and medium-fat contents are evaluated for freshness, with quite good agreement between sensory judgments and these freshness criteria.

The complicating nature of fatty changes superimposed on the ordinary spoilage pattern is further shown by the data for the fish with a high fat content, such as salmon and tuna. For these fish the TMN content had little significance, both before and after an incubation period. The VRS content had more significance in relation to spoilage, and at certain stages increases were observed after an incubation period, particularly for salmon. However, as found previously, at certain stages of rancidification of the fat no appreciable increases in VRS occurred, even though sensory changes were noticeable. In the more advanced stages of fat spoilage, when other spoilage changes were also noticeable, marked increases in VRS content were found. For the fatty fish the percentage of pigmented bacteria before and after an incubation period had a greater value as a freshness criterion than did the TMN values. As a result, the determinations of VRS and percentage of pigmented bacteria, along with the sensory judgment, generally enabled a reasonably accurate evaluation of freshness. For the shrimp the situation was similar to that for the low-fat fish. The VRS and TMN contents before and after incubation enabled a good estimate of freshness. No data for pigmented bacteria were available. When such data are obtained their correlation with these two criteria will be noted. In some cases a progressive decrease in the content of the chemical criteria was found during the course of incubation. This will be studied in greater detail to determine its validity and significance.

A number of questions regarding the three criteria for freshness remain to be answered. Among these are the effects of storage temperature, time of storage, of species of fish and shellfish, and of antioxidants for the fatty fish, as well as the significance and causes of the changes in bacterial flora during the early stages of storage and the possible effects of the products of fat rancidification on the bacterial growth. For example, it has been reported that certain fish-liver oils possess bactericidal properties (Leusden and Derlich, 1940). It is possible that the decreased effectiveness of the incubation period to accelerate spoilage in the case of the fatty fish reflects an inhibitory effect of the rancidification products on the growth of bacteria.

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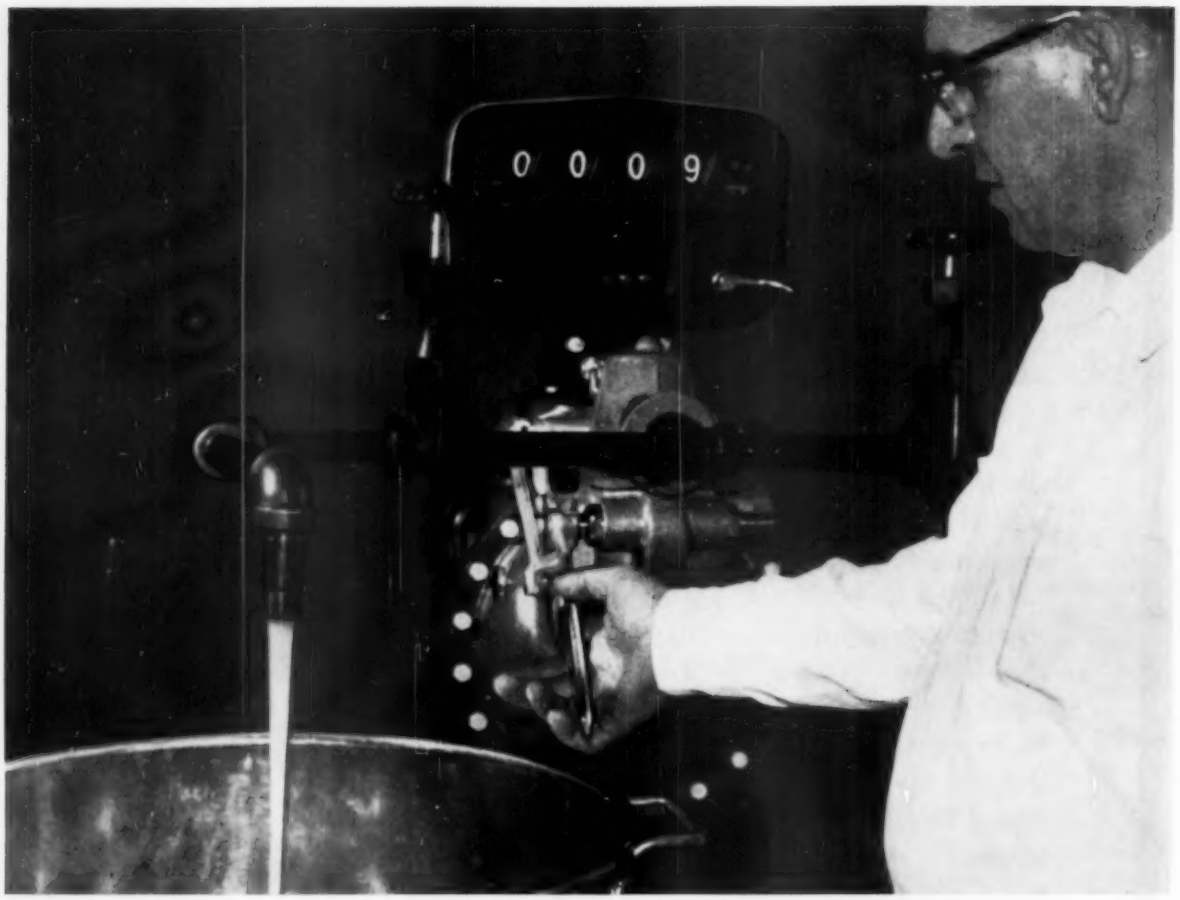

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(Manuscript received June 15, 1960)

SUMMARY

The effects of pre-rigor infusion of a chelating agent at various levels on the tenderness of beef was studied. Twenty-one cutter and canner cow rounds were infused with 10, 15, and 20% solutions of sodium hexametaphosphate, and a 15% solution plus lactic acid (pH 5.8). The corresponding control rounds were infused similarly with tap water. Tenderness, as recorded by taste panel and shear, was improved by pre-rigor infusions of all chelating solutions, and no one level improved tenderness more than other levels. A highly significant negative correlation of −.42 existed between taste-panel scores and shear values. Extractable nitrogen was not a reliable indication of tenderness. The pH values were higher and glycogen values lower for treated samples at 48 hours than at zero hours, indicating that glycolysis was not interrupted by infusion.

A NUMBER of workers (Harrison *et al.*, 1949; Hiner *et al.*, 1955; Lloyd and Hiner, 1958; Miller and Kastelic, 1956; Mitchell *et al.*, 1928; Orme *et al.*, 1958; Saffle and Bratzler, 1959; Wang *et al.*, 1956; Wierbicki *et al.*, 1954) have indicated that much of the variation in the tenderness of muscles is due to factors other than connective tissue. Dodge and Stadelman (1959), Gainer *et al.* (1951), de Fremary and Pool (1960), and Paul *et al.* (1952) associated tenderness with the pattern of rigor after the slaughter of the animal.

In more basic studies, Szent-Gyorgyi (1951), Marsh (1952), and Bendall (1958) found that actomyosin was formed during the onset of rigor. The formation of this protein was affected by Ca, K, and Mg ions, ATP, and a muscle-relaxing factor. Wierbicki *et al.* (1956) suggested that actomyosin may account for the initial toughening of meat after slaughter.

This study was conducted to determine the effect of an infusion of sodium hexametaphosphate solution into hot beef rounds to improve tenderness. The experiment was designed to interrupt the normal sequence of rigor by infusing a chelating agent, as suggested by work (Kamstra and Saffle (1959)) on paired hams. Glycogen content, lactic acid content, pH, and extractable nitrogen were determined.

EXPERIMENTAL

Fifty-four rabbits were used in preliminary work in an attempt to determine the chelating compounds and levels that would produce desired tenderness. Difficulty was encountered in infusing the legs with chelating compounds to an increase of 5% over initial weight, because of massive tetany upon infusion. No conclusive results were obtained from this preliminary work.

Hot beef rounds were removed from cutter and canner cow carcasses as soon as slaughter was completed. The left round was infused via the femoral artery with the following levels and compounds to an increase of 5% over initial weight: sodium hexametaphosphate, 10% (7 rounds), 15% (5 rounds), 20% (5 rounds); sodium hexametaphosphate and lactic acid (to a pH of 5.8), 15%.

The right, or control, round of the same pairs was infused similarly with tap water. Both control and treated rounds were stored in a $3 \pm 1°C$ cooler until slices were cut for shear and taste-panel analyses. At infusion, a sample weighing about 4 oz was cut from the face of the round, which consisted of the *Vastus intermedius*, *Vastus lateralis*, and *Vastus medialis* muscles. This sample was freeze-dried and ground in a Wiley mill and stored in labeled bottles in a desiccator until chemical analysis.

The pH of each round was taken at 0, 24, and 48 hours with a Beckman portable pH meter. Glycogen and lactic acid contents of the muscle were determined from a portion of the freeze-dried samples taken at 0 and 48 hours. The method of Cowgill and Pardee (1957) was used for glycogen analysis, and lactic acid determination was by the Official Methods of Analysis (Assoc. Offic. Agr. Chemists, 1955). Results were expressed as per cent of dried sample.

At 48 hours the rounds were removed from the cooler, and two 1-in.-thick slices were cut 1 in. posterior and parallel to the aitch bone for taste-panel and shear samples. For taste-panel use, the *Semimembranosus* muscle from the second slice was cooked to an internal temperature of 170°F in deep fat held at 300°F. Treated and control samples were cooked at the same time. Coded paired samples were served to the 8 trained taste-panel members, who scored them on a hedonic scale (1 = extremely tough, 9 = extremely tender).

Samples for shear, obtained from the *Semitendinosus*, *Semimembranosus*, and *Biceps femoris* of the first round slice, were cooked in a similar manner. Average shear force, as determined by Warner-Bratzler Shear, for eight ½-in. cores was used as the shear tenderness score for that muscle.

Fresh samples taken from the *Biceps femoris* muscle of the second slice cut from treated and control rounds at 48 hours were analyzed for the per cent extractable nitrogen by the method of Wierbicki *et al.* (1956). This method was used as an estimate of the actin, myosin, and actomyosin content of the muscle. Extractable nitrogen was expressed as per cent of total nitrogen in the fresh sample.

RESULTS AND DISCUSSION

Taste-panel scores and maximum shear values indicated a greater tenderness preference for treated samples than for control samples (Table 1). The average taste-panel scores showed: of the 21 paired samples, 19 treated samples were preferred over controls, 1 pair rated even, and 1 control was preferred over the treated sample. Analysis of variance of taste-panel scores showed a highly significant difference of treated samples over control samples in all cases except the 15% solution (significant at the 5% level) and the 20% solution (approaching significance).

[a] Data from an M.S. thesis by the senior author.

[b] Approved for publication by the Director of the South Dakota Agricultural Experiment Station as No. 485 of the Journal Series.

[c] Present address: Food Technology Department, University of Georgia, Athens.

Table 1. Means for taste-panel, shear, and extractable-nitrogen values.

	Concentration of sodium hexametaphosphate				
	Control	10%	15%	20%	15% + lactic acid
Taste-panel scores [a]	3.01	3.51	3.65	4.60	4.68
Shear [b]					
Semitendinosus	16.99	13.97	13.39	15.42	16.72
Semimembranosus	14.70	11.35	11.63	12.24	12.77
Biceps femoris	17.42	12.96	12.62	14.59	18.78
Extractable nitrogen [c]	25.52	25.47	25.80	24.38	22.38

[a] Scored on a hedonic scale (1 = extremely tough; 9 = extremely tender).
[b] Maximum shear values as obtained by Warner-Bratzler Shear.
[c] Expressed as per cent of total nitrogen in the fresh sample.

A significant difference existed between treated and control rounds for shear of the *Biceps femoris* muscle. The studentized range indicated that, for the *Biceps femoris* muscle, the rounds treated with 10, 15, and 20% solutions were significantly different from control rounds and from rounds treated with the 15% solution plus lactic acid.

The means for the *Semitendinosus* and *Biceps femoris* muscles (Table 1) of the 15% solution plus lactic acid were nearly equal to or greater than control rounds. No apparent reason can be given for these results. The results of both taste panel and shear for the *Semimembranosus* muscle showed that those treated with the 15% solution plus lactic acid were considerably more tender than control rounds. The means (Table 1) for maximum shear values of *Semimembranosus* and *Semitendinosus* muscles were less in every case for treated rounds than for control rounds, which indicated that more tender rounds resulted from treatment, although they only approached significance.

A highly significant negative correlation coefficient, of –.42, existed between taste-panel and shear results. The over-all results of taste panel and shear showed a decided advantage in tenderness for treated rounds over control rounds. Certain other characteristics, such as dark color and flabbiness of treated rounds, were noted. The dark color of the rounds treated with 10, 15, and 20% solutions was not present in those infused with 15% plus lactic acid solution. However, all treated rounds were somewhat flabby.

Analysis of variance revealed a highly significant difference between control and treated samples for glycogen at 48 hours. The lower glycogen values were possibly due to the buffering action of chelating solutions, which caused the pH to remain higher and thus permitted more glycogen to be dissipated than in control samples (Table 2). This was also an indication that infusion of a sodium hexametaphosphate solution did not interrupt glycolysis in treated samples. These results contradict those of Kamstra and Saffle (1959).

As would be expected, negative correlations between lactic acid and glycogen were found in both treated and control samples at both 0 and 48 hours, because of the formation of lactic acid from glycolysis.

All treated samples except rounds infused with 15% solution plus lactic acid had a higher final pH than the corresponding controls (Table 2). These results agree with those of Kamstra and Saffle. The respective mean values for extractable nitrogen of treated and control samples at 48 hours were 24.70 and 25.36% nitrogen (Table 1). The results indicate that slightly more actin and myosin were present in control than treated samples. The difference, however, was too small to be conclusive.

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Table 2. Means for glycogen and pH values at 0 and 48 hours.

	Concentration of sodium hexametaphosphate							
	10%		15%		20%		15% + lactic acid	
	Control	Treated	Control	Treated	Control	Treated	Control	Treated
% glycogen [a]								
0 hours	.....	.....	2.90	2.90	1.50	1.50	1.25	1.25
48 hours	1.06	0.82	0.44	0.24	0.76	0.58	0.21	0.12
pH								
0 hours	6.60	7.10	6.94	7.08	7.26	7.52	6.75	6.92
24 hours	5.90	5.89	6.26	6.38	5.98	6.28	6.25	6.05
48 hours	5.86	5.93	6.00	6.16	5.88	6.30	5.95	5.95

[a] Expressed as per cent of dried sample.

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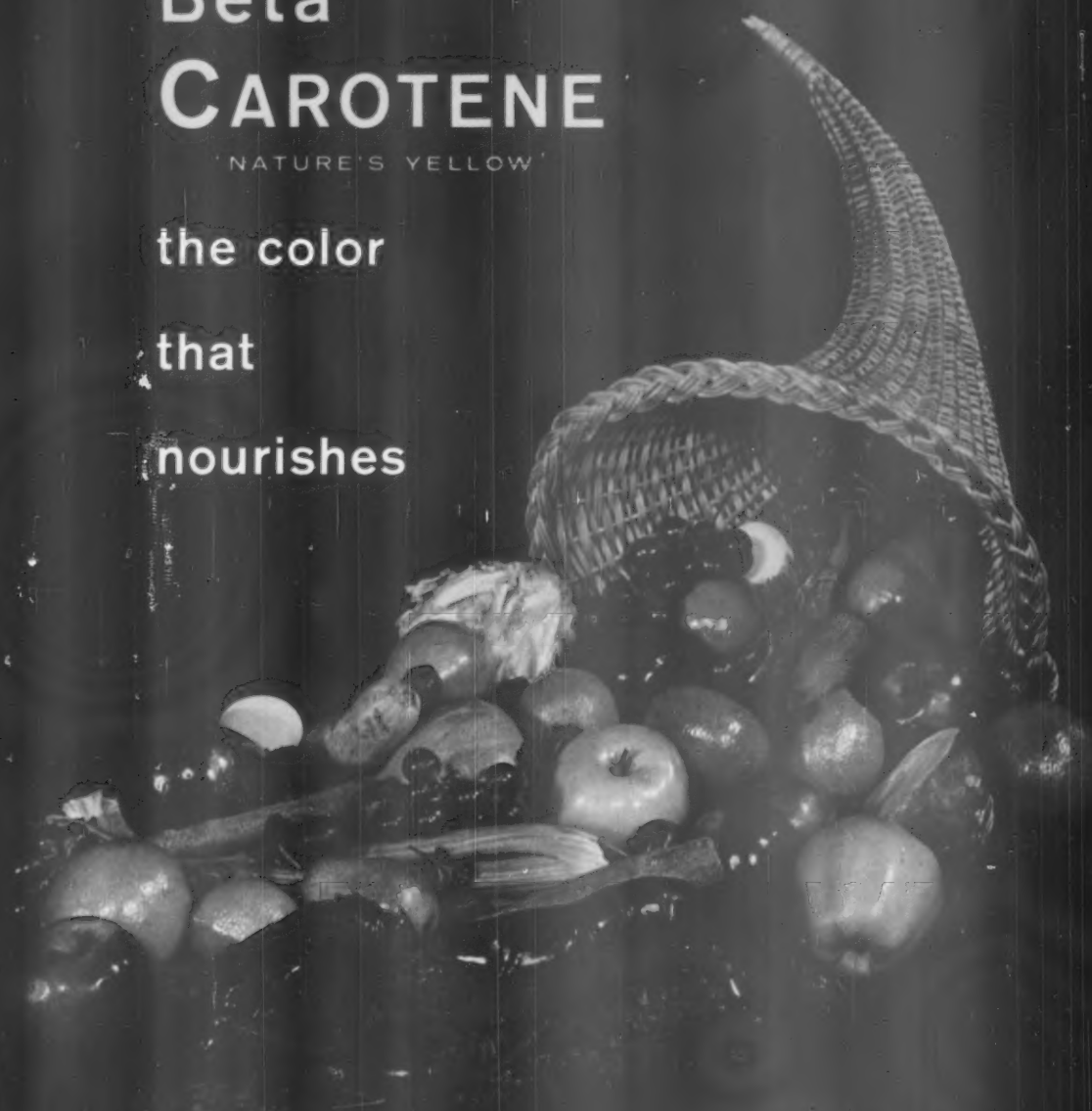

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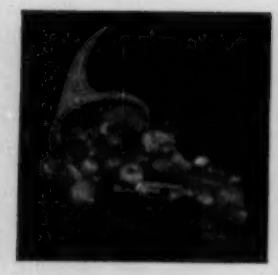

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TECHNICAL PROGRAM

AND

GENERAL AND SOCIAL EVENTS

Twenty-first Annual Meeting

of the

Institute of Food Technologists

May 7 through May 11, 1961

New York, New York

General Information

REGISTRATION

The Registration Desk is located on the Mezzanine Floor near elevators in the Statler Hilton Hotel. Pre-registrants may pick up their badges and tickets starting at 10:00 A.M. Saturday, May 6.

REGISTRATION FEES

Members	$10.00
Non-members	15.00
Student Members	2.00
Student Non-members	3.00
Exhibitors—6 for each exhibit	Free
Exhibitors—6 additional—each	5.00
Exhibitors—(in excess of 12) each	— applicable fee
Wives or Husbands of Members	Free

HEADQUARTERS ROOMS

IFT Headquarters	Boston Room, Mezzanine
Convention Committee Headquarters—	Buffalo Room, Mezzanine
Press Room	Dartmouth Room
Employment	Village Room and Town Room, First Guest Room Floor
Ladies' Hospitality Room	Pennsylvania-Cornell Rooms
Courtesy and Information	Registration Area, Mezzanine

COURTESY AND INFORMATION

An information desk and bulletin board will be located in the registration area for your convenience in locating registrants, posting messages, and obtaining information about the city and the convention, during registration hours. Personnel on hand will assist in the distribution of "lost" mail, and maintain a "lost and found" service.

Theater ticket information and order forms for the Monday evening Nite Life Party will be available. Also available will be free studio tickets for evening TV shows, passes to visit some trans-Atlantic liners in port, discount coupons for tours of the Radio City NBC Television Studios, the American Museum-Hayden Planetarium, Rockefeller Center and the Empire State Building Observatory, and for local boat trips. Information about visits to the United Nations and Freedomland will be on hand. As a special service to gourmets, menus of famous midtown restaurants will be displayed.

TICKETS

Tickets are required for all social events, ladies' tours, field trips, banquet, organized breakfasts and luncheons, etc. Ticket sales are limited to registered personnel presenting badges and ticket order forms at least twelve hours prior to the event in order to guarantee accommodations. There will be no refund on tickets less than twelve hours prior to an event. For your convenience, each field trip ticket has been printed on different colored stock. For easy identification, a large card of matching color will appear in the window of your bus.

EXHIBITS

All exhibits are located in the Mezzanine Exhibit Area and Georgian Room. Admission to these areas is limited to registered personnel presenting badges.

Exhibit visiting hours are:

Sunday, May 7	1:00 P.M. to 5:00 P.M.
Monday, May 8	11:00 A.M. to 4:30 P.M.
Tuesday, May 9	11:00 A.M. to 4:30 P.M.
Wednesday, May 10	11:00 A.M. to 4:00 P.M.

There has often been tangible evidence of the value of visiting each of the exhibits. Under one roof are many items of interest that would ordinarily take months to investigate. On display this year will be the finest and most recent developments in products, processes, and equipment, and informed personnel will be available to answer your questions.

EMPLOYMENT

A new IFT Employment Bureau, using a new system designed to ensure that absolutely no confidences are divulged, will be operated in the Towne Room and Village Room (first guest room floor) of the Statler Hilton Hotel. The service offers an anonymous listing of position vacancies within the food industry, and an anonymous listing of available food technologists.

It is necessary to have all position vacancy and individual availability listings at IFT Headquarters in Chicago no later than April 21st. Processing in a confidential manner necessarily takes time, therefore listings received at the Annual Meeting will probably not be used until after May 15th.

Hours of operation are:

Sunday	1:00 P.M. to 4:30 P.M.
Monday	8:00 A.M. to 4:30 P.M.
Tuesday	8:00 A.M. to 4:30 P.M.
Wednesday	8:00 A.M. to 4:30 P.M.

LADIES ENTERTAINMENT

For the convenience of the ladies, a hospitality lounge is maintained in the Pennsylvania and Cornell Rooms of the Statler Hilton, and New York Section Hostesses will be present. Coffee will be served in the morning, and in the afternoon tea will be available. A limited supply of radio and television tickets are also available, and you are invited to make this your meeting place.

Hours:

Monday	8:30 A.M. to 5:00 P.M.
Tuesday	8:30 A.M. to 4:00 P.M.
Wednesday	8:30 A.M. to 5:00 P.M.

On Sunday all ladies are invited to attend the welcoming tea in the Pennsylvania and Cornell Rooms from 2:30 to 4:30 in the afternoon. Please come and get acquainted.

At 9:15 on Monday morning buses will leave from the 32nd Street Exit of the Hotel for a sightseeing cruise around Manhattan Island. Transportation will then be

provided to the exotic Luau 400 Restaurant, where you will be entertained with a luncheon and floor show presented in enchanting tropical splendor. The remainder of the afternoon will be open for you to explore New York on your own.

Tuesday at 9:15 A.M. buses will be ready for boarding at the 32nd Street Exit of the Hotel for a trip through Westchester County. Tour destination will be the famous General Foods Kitchens. Next stop will be Patricia Murphy's Candelight Restaurant, with its gift shop and surrounding beautiful gardens. Return to the Statler around 3:30 P.M.

On Wednesday at 10:30 A.M., after coffee in the Hospitality Suite, buses will leave the 32nd Street Exit of the Hotel for a tour of the National Design Center where visitors will see the latest concepts in household decorating. Next will be luncheon at the famous Leone's Restaurant, and then on to a matinee (reserved seats) at Radio City Music Hall, home of the world-famous Rockettes.

Please note that tickets to all of these very delightful events are limited in number. We ask that you secure yours well in advance, so as not to be disappointed.

FIELD TRIPS

For each of the field trips listed, there are a maximum number of individuals that can be accommodated. Tickets will be distributed on a first-come first-served basis to all registered applicants and their wives. In the event a given quota is filled, the fare will be refunded at the registration desk. BUSES FOR ALL FIELD TRIPS DEPART FROM THE 32ND STREET EXIT OF THE HOTEL.

North Tour—General Foods Laboratories; National Biscuit Company

Depart 8:00 a.m.—return 5:00 p.m., limit 100 people, price $4

A visit to the largest technical operation in the packaged food industry where General Foods employs more than 600 scientists, technicians, and supporting service personnel. Luncheon, courtesy of General Foods at 11:30 Afternoon tour through National Biscuit Company's $15,000,000 plant which produces 175 million pounds of cookies and crackers a year. The automatic baking process will be seen, from raw material storage to the finished product.

South Tour—Rutgers University; Walker Gordon Certified Milk Farm; Firmenich, Inc.; Princeton University

Depart 8:00 a.m.—return 5:00 p.m., limit 80 people, price $4.00

The Institute of Microbiology and Food Science Department will be visited at Rutgers, followed by a tour through the world's largest certified milk farm and a demonstration of the Walker Gordon Rotolactor. A Firmenich plant tour and visit to their flavor research center will precede a complimentary Pennsylvania Dutch Luncheon by Firmenich. On the way home, IFT'ers will see the 2,200-acre Princeton University campus.

International Flavors & Frangrances Inc.

Depart 8:00 a.m.—return 2:00 p.m., limit 45 people, price $2.50

Available for inspection will be the company's pilot plant, equipped with instrumentation laboratories, and quality control facilities, as well as production facilities including distillation equipment, filters, reactors, and evaporators. A complimentary luncheon will be provided by IFF at Peterson-Buttonwood Manor.

Hoffmann-La Roche Inc.

Depart 8:15 a.m.—return 1:15 p.m., limit 35 people, price $2.50

This tour will encompass a visit to the world's largest vitamin A plant showing manufacturing, blending, and canning operations, as well as a visit through the new development building which started operations on April 1st. There will be a Hoffmann-La Roche luncheon at 11:30.

Merck & Co., Inc.

Depart 8:15 a.m.—return 1:15 p.m., limit 45 people, price $2.50

Three Merck areas will be visited: Product Development Laboratories, Fundamental Developmental and Industrial Research Laboratories, and the Merck Institute of Therapeutic Research. Guests will be informed of the activities of the various divisions including research, development and manufacturing facilities, and product line, with emphasis on the food segment of Merck's Chemical Division interests. Merck will serve a complimentary luncheon at 11:30.

Anheuser-Busch, Inc.

Depart 1:30 p.m.—return 5:00 p.m., limit 45 people, price $2.00

Tracing a grain of barley to a glass of beer will be accomplished through visits to the power house, brew house, starting cellars, fermenting cellars, lagering cellars, filter room, bottle shop, can filling area, palletizers, and warehouse area. Another area called Rathskeller will be visited upon completion of the tour, and this is said to be a place of relaxation.

Food and Drug Research Laboratories, Inc.

Depart 1:30 p.m.—return 5:00 p.m., limit 45 people, price $2.00

In touring the 30,000 square feet of laboratories, visitors may expect to see some or all of the following: automated amino acid assays; gas chromatography; infrared analysis; radioisotope tracer studies; semi-automated histological techniques; taste panel evaluations; electrophysiological measurements; and a colony of more than 20,000 laboratory animals of various species involved in toxicological and nutritional investigations.

Thomas J. Lipton, Inc.

Depart 1:30 p.m.—return 5:00 p.m., limit 45 people, price $2.00

Visitors will tour through pilot facilities being used to investigate dehydrated foods, plus see a movie presenting equipment and techniques involved in freeze drying. Present and future potential in using freeze drying as a food preservation procedure will be discussed.

General and Social Events

FRIDAY, MAY 5, 1961

Executive Committee Meeting
9:00 A.M.—5:00 P.M.—Empire Suite A

SATURDAY, MAY 6, 1961

Registration and Tickets
10:00 A.M.—5:00 P.M.—Mezzanine

SUNDAY, MAY 7, 1961

Registration and Tickets
8:30 A.M.—5:00 P.M.—Mezzanine
6:30 P.M.—8:00 P.M.—Penn Top and Skytop, 18th Floor

Council Meeting
10:00 A.M.—4:00 P.M.—Gold Ball Room

Exhibits—Official Opening
1:00 P.M.—5:00 P.M.—Mezzanine Area and Georgian Room

Ladies' Welcome Tea
2:30 P.M.—4:30 P.M.—Pennsylvania-Cornell Rooms

Press Conference
4:00 P.M.—6:00 P.M.—Dartmouth Room

Social Hour (all registrants)
6:30 P.M.—Penn Top and Skytop, 18th Floor

MONDAY, MAY 8, 1961

Section Officers' Breakfast
7:30 A.M.—East Room, Mezzanine

University of California Breakfast
7:30 A.M.—Penn Top North, 18th Floor

Pennsylvania State University Breakfast
7:30 A.M.—Penn Top South, 18th Floor

University of Wisconsin Breakfast
7:30 A.M.—Empire Suite, 1st Guest Room Floor

Ladies' Hospitality Lounge
8:30 A.M.—5:00 P.M.—Pennsylvania-Cornell Rooms

Registration and Tickets
8:30 A.M.—5:00 P.M.—Mezzanine

General Session
8:45 A.M.—10:15 A.M.—Grand Ball Room, Mezzanine

Ladies' Cruise and Luncheon
9:15 A.M.—Buses leave from 32nd Street Exit

Symposium—Role of Food Technology in Civil Defense
10:20 A.M.—12:00 NOON—Grand Ball Room, Mezzanine

Technical Sessions
10:20 A.M.—12:00 NOON—Gold Ball Room; Skytop, 18th Floor; West Room, Mezzanine

Exhibits
11:00 A.M.—4:30 P.M.—Mezzanine Area and Georgian Room

University of Massachusetts Luncheon
12:00 NOON—Penn Top North, 18th Floor

Technical Sessions
1:40 P.M.—5:00 P.M.—Grand Ball Room, Mezzanine; Gold Ball Room; Skytop, 18th Floor; West Room, Mezzanine

TUESDAY, MAY 9, 1961

Massachusetts Institute of Technology Breakfast
7:30 A.M.—East Room, Mezzanine

University of Minnesota Breakfast
7:30 A.M.—Gold Ball Room Foyer

Purdue University Breakfast
7:30 A.M.—Empire Suite, 1st Guest Room Floor

Rutgers-The State University Breakfast
7:30 A.M.—Headquarters Room, 18th Floor

Ladies' Hospitality Lounge
8:30 A.M.—4:00 P.M.—Pennsylvania-Cornell Rooms

Registration and Tickets
8:30 A.M.—5:00 P.M.—Mezzanine

General Session—Symposium—Food Science and Feeding Mankind
8:40 A.M.—12:00 NOON—Penn Top, 18th Floor

Ladies' Tour, General Foods Kitchens; luncheon at Patricia Murphy's
9:15 A.M.—Buses leave from 32nd Street Exit

Exhibits
11:00 A.M.—4:30 P.M.—Mezzanine Area and Georgian Room

University of Illinois Luncheon
12:00 NOON—East Room, Mezzanine

General Session—Babcock-Hart Award Address
1:30 P.M.—2:15 P.M.—Penn Top, 18th Floor

Symposium—Food Additives
2:20 P.M.—5:00 P.M.—Penn Top, 18th Floor

Technical Sessions
2:20 P.M.—5:00 P.M.—Gold Ball Room; Skytop, 18th Floor; West Room, Mezzanine

Awards Banquet
7:00 P.M.—Grand Ball Room, Mezzanine

WEDNESDAY, MAY 10, 1961

Canadian Breakfast
7:30 A.M.—Penn Top North, 18th Floor

University of Georgia Breakfast
7:30 A.M.—Penn Top South, 18th Floor

Oregon State Breakfast
7:30 A.M.—Empire Suite, 1st Guest Room Floor

Phi Tau Sigma Breakfast
7:30 A.M.—East Room, Mezzanine

Ladies' Hospitality Lounge
8:30 A.M.—5:00 P.M.—Pennsylvania-Cornell Rooms

Registration and Tickets
8:30 A.M.—12:00 NOON—Mezzanine

Symposium—Statistical Quality Control
8:40 A.M.—12:00 NOON—Skytop, 18th Floor

Technical Sessions
8:40 A.M.—12:00 NOON—Grand Ball Room, Mezzanine; Gold Ball Room; West Room, Mezzanine

Ladies' Tour, Design Center, Radio City, Luncheon
10:30 A.M.—Buses leave from 32nd Street Exit

Exhibits (Final Day)
11:00 A.M.—4:00 P.M.—Mezzanine Area and Georgian Room

General Session—Nicholas Appert Award Address
1:30 P.M.—2:10 P.M.—Grand Ball Room, Mezzanine

Business Meeting
2:10 P.M.—2:35 P.M.—Grand Ball Room, Mezzanine

Symposium—Education of a Food Technologist
2:40 P.M.—5:00 P.M.—Grand Ball Room, Mezzanine

Technical Sessions
2:40 P.M.—5:00 P.M.—Gold Ball Room; Skytop, 18th Floor; West Room, Mezzanine

Exhibitors Prize Drawing
5:10 P.M.—Grand Ball Room, Mezzanine

THURSDAY, MAY 11, 1961

Field Trips.
All buses leave promptly from the 32nd Street Exit

8:00 A.M.—5:00 P.M.—General Foods Laboratories, Tarrytown, N. Y., luncheon, compliments of General Foods. National Biscuit Company, Fairlawn, N. J.

8:00 A.M.—5:00 P.M.—Rutgers-The State University, Walker Gordon Certified Milk Farm, Firmenich, Inc., luncheon, compliments of Firmenich. Princeton University Campus.

8:15 A.M.—2:00 P.M.—International Flavors & Fragrances Inc., Union Beach, N. J. luncheon at Peterson-Buttonwood Manor, compliments of IFF.

8:15 A.M.—1:15 P.M.—Hoffmann-La Roche Inc., Nutley, N. J., luncheon, compliments of Hoffmann-La Roche.

8:15 A.M.—1:15 P.M.—Merck & Co., Inc., Rahway, N. J., luncheon, compliments of Merck.

1:30 P.M.—5:00 P.M.—Anheuser-Busch Inc., Newark, N. J.

1:30 P.M.—5:00 P.M.—Food & Drug Research Laboratories, Inc., Maspeth, L. I., N. Y.

1:30 P.M.—5:00 P.M.—Thomas J. Lipton, Inc., Hoboken, N. J.

NOW is the time to plan ahead

Now that you have reviewed the Technical Papers to be presented, and read about many of the products, processes, and new types of equipment to be exhibited, you should be better equipped to justify your attendance at the 1961 Annual Meeting.

Over-all, the 21st IFT Convention will feature:

—most authoritative and up to the minute processing information

—newest equipment, instruments, ingredients, technological advances

—local, national, and international food field for the '60's

The 1961 Program seems to cover most of the food field, with sessions scheduled in the areas of flavors, microbiology, dehydration, fruits and vegetables, pressurized food products, packaging food products, meat and fish, colors and flavors, pigments and lipids in animal products, radiation, statistical techniques, process engineering and general research. Exhibitors will display wares including irradiation equipment, ingredients, instruments, machinery, cleaners and sanitizers, and packaging material and equipment. They will have technical personnel on hand to intelligently answer questions.

According to one 1960 exhibitor: "We're happy to report that this year's Institute of Food Technologist's show in San Francisco was one of the best-attended and most valuable convocations in memory."

Our 1960 convention also elicited this remark from IFT President Dr. Hutchings: "The attendance of the food industry's top research and engineering quality control and top management personnel is excellent and growing every year . . . the calibre and diversity of technical programs, exhibits and personal contacts make the IFT convention a rewarding experience."

With a more concentrated program encompassing the entire field of food technology, and nearly forty exhibitors and booths this year, a food technologist can ill afford to miss this only comprehensive Food Industry Convention.

THE TECHNICAL PROGRAM

IN SUMMARY

Monday Morning—May 8

8:45—10:15

General Session—Grand Ball Room, Mezzanine

10:20—12:00 Noon

Technical Sessions

Section 1A—Symposium—Role of Food Technology in Civil Defense—Grand Ball Room, Mezzanine

Section 1B—Microbiology and Public Health—Gold Ball Room

Section 1C—Enzymes—Skytop, 18th Floor

Section 1D—General Research—West Room, Mezzanine

Monday Afternoon

1:40—5:00

Technical Sessions

Section 2A—Flavors—Grand Ball Room, Mezzanine

Section 2B—Microbiology—Gold Ball Room

Section 2C—Dehydration—Skytop, 18th Floor

Section 2D—Fruits and Vegetables—West Room, Mezzanine

Tuesday Morning—May 9

8:40—12:00 Noon

General Session—Symposium—Food Science and Feeding Mankind—Penn Top and Skytop, 18th Floor

Tuesday Afternoon

1:30—2:15

General Session

Babcock-Hart Address—Penn Top, 18th Floor

2:20—5:00

Technical Sessions

Section 4A—Symposium—Food Additives—Penn Top, 18th Floor

Section 4B—Fruits and Vegetables—Quality Aspects—Gold Ball Room

2:20—4:00

Section 4Ca—Pressurized Food Products—Skytop, 18th Floor

4:00—5:00

Section 4Cb—Packaging Food Products—Skytop, 18th Floor

2:20—5:00

Section 4D—Meat and Fish—Structure and Texture—West Room, Mezzanine

Wednesday Morning—May 10

8:40—12:00 Noon

Technical Sessions

Section 5A—Colors and Flavors—Grand Ball Room, Mezzanine

Section 5B—General Research—Gold Ball Room

Section 5C—Symposium—Statistical Quality Control—Skytop, 18th Floor

Section 5D—Pigments and Lipids in Animal Products—West Room, Mezzanine

Wednesday Afternoon

1:30—2:10

General Session

Nicholas Appert Award Address—Grand Ball Room, Mezzanine

2:10—2:35

Business Meeting—Grand Ball Room, Mezzanine

2:40—5:00

Technical Sessions

Section 6A—Symposium—Education of a Food Technologist—Grand Ball Room, Mezzanine

Section 6B—Microbiology—Radiation—Gold Ball Room

2:40—3:40

Section 6Ca—Statistical Techniques—Skytop, 18th Floor

3:45—5:00

Section 6Cb—Process Engineering—Instrumentation—Skytop, 18th Floor

2:40—5:00

Section 6D—Meat and Fish—Bacterial and General—West Room, Mezzanine

THE TECHNICAL PROGRAM IN DETAIL

MONDAY MORNING—MAY 8

General Session

Grand Ball Room, Mezzanine

Chairman: FRED C. BASELT
American Can Company, New York

8:45 Call To Order

8:50 "Welcome"
B. L. OSER, Food and Drug Research Laboratories, Inc.

8:55 "Your Committee Has Arranged—"
E. P. ORSAY, International Flavors & Fragrances, Inc.

9:00 Presidential Address
I. J. HUTCHINGS, H. J. Heinz Company

9:30 Scholarship and Fellowship Awards
H. L. SIPPLE, The Nutrition Foundation, Inc.

10:00 Food Technology Industrial Achievement Award
P. K. BATES, Carnation Company

Concurrent Sessions

Section 1A—Grand Ball Room, Mezzanine

SYMPOSIUM
Role of Food Technology in Civil Defense

Moderator: R. H. FORSYTHE
Iowa State University

10:20 Introduction

10:25— 1. Capabilities of Chemical, Biological and Radiological (CBR) Warfare Agents
F. L. PARNELL, OCDM, Washington, D. C.

10:50— 2. Biological Warfare Hazards in Processed Foods
KEITH LEWIS, U. S. Public Health Service, Cincinnati, Ohio

11:05— 3. Radiological Warfare Hazards in Processed Foods
H. KRAYBILL, U. S. Public Health Service, Washington, D. C.

11:20— 4. Maintaining the Food Supply
B. M. EASTON, U. S. Department of Agriculture, Commodity Stabilization Service

11:40— 5. Maintaining the Food Safety
S. GRAY, Department of Health, Education, and Welfare

MONDAY MORNING—MAY 8

Section 1B—Gold Ball Room

Microbiology and Public Health

Chairman: C. S. PEDERSON
Cornell University

10:20— 6. Occurrence of Enterocci and Coliform Organisms on Fresh and Stored Poultry
W. B. WILKERSON, JOHN C. AYRES, and A. A. KRAFT, Iowa State University of Science and Technology

10:40— 7. A Comparison of Various Techniques Used in the Isolation of Coagulase Positive Staphylococci
GERALD SILVERMAN, J. T. R. NICKERSON, DOUGLAS DUNCAN, Massachusetts Institute of Technology

11:00— 8. Growth and Toxin Production by Type E Clostridium Botulinum Below 40° F.
C. F. SCHMIDT, R. V. LECHOWICH, and J. F. FOLINAZZO, Continental Can Company, Inc.

11:20— 9. Survival Curve of Cl. Botulinum Spores
E. WHEATON and G. B. PRATT, American Can Company

11:40— 10. Survival of Bacteria of Public Health Significance in Frozen Seafoods
H. ROJ and J. LISTON, University of Washington

MONDAY MORNING—MAY 8

Section 1C—Skytop, 18th Floor

Enzymes

Chairman: H. LINEWEAVER
Western Regional Research Laboratory

10:20— 11. Activity of Microbial Lipases at Temperatures Below 0° C.
JOHN A. ALFORD and DAVID A. PIERCE, Eastern Utilization Research & Development Division, U. S. Department of Agriculture

10:40— 12. A Study of the Enzyme System in Peas (Pisum sativum)
E. von SYDOW and C. ERIKSSON, Swedish Institute for Food Preservation Research

11:00— 13. Factors Affecting the Water Retention of Beef. V. Variation of the Zinc-Containing Enzymes
M. D. BERMAN, U. S. Department of Agriculture, Eastern Regional Research Laboratory

11:20— 14. Pectin Methylesterase in Snap Beans
J. P. VAN BUREN, J. C. MOYER, W. B. ROBINSON, and D. B. HAND, Cornell University

11:40— 15. The Stability and Activity of Bound vs. Soluble Enzymes
EUGENE F. JANSEN, Western Regional Research Laboratory, U. S. Department of Agriculture

MONDAY MORNING—MAY 8

Section 1D—West Room, Mezzanine

General Research

Chairman: C. O. BALL
Rutgers University

10:20— 16. The Theoretical Formulae of Temperature at an Arbitrary Point in Thermally Conductive Canned Food in the Cooling Phase of a Heat Process
KAN-ICHI HAYAKAWA, Rutgers University

10:40— 17. Application of Extreme-Value Methods and Other Statistical Procedures to Heat-Penetration Data

JOHN J. POWERS, DAN E. PRATT, JAMES L. CARMON, and DARDJO SOMAATMADJA, University of Georgia

11:00— 18. Some Physico-Chemical Relationships in Cleaning Hard Surfaces

WALTER G. JENNINGS and MALCOLM C. BOURNE, University of California

11:20— 19. Changes in pH of Some Frozen Foods During Storage

L. van den BERG, National Research Council (Canada)

11:40— 20. Automtic Recording of Vibrational Properties of Foodstuffs (Presented by E. von Sydow)

B. DRAKE, Swedish Institute for Food Preservation Research

MONDAY AFTERNOON—MAY 8

Section 2A—Grand Ball Room, Mezzanine

Flavors

Chairman: A. S. WENDT

Fred Fear & Company

1:40— 21. Special Columns for GLC Separation of Essential Oils

K. P. DIMICK and C. ABMA, Wilkins Instrument & Research, Inc.

2:00— 22. Quantitative Study of Monoterpene Hydrocarbons in Cold-Pressed Citrus Oils

R. M. IKEDA, W. L. STANLEY, L. A. ROLLE, and S. H. VANNIER, Western Regional Research Laboratory, U. S. Department of Agriculture

2:20— 23. Seasonal Study of Major Aldehydes in Lemon and Orange Oils

W. L. STANLEY, R. M. IKEDA, S. H. VANNIER, and L. A. ROLLE, Western Regional Research Laboratory, U. S. Department of Agriculture

2:40— 24. Organic Acids in Fruit Juices

D. JORYSCH, P. SARRIS, and S. MARCUS, H. Kohnstamm and Co., Inc.

3:00— 25. Volatile Esters of Bartlett Pears

WALTER G. JENNINGS, University of California

3:20— 26. Some Flavor Components in Black Currants (Ribes nigrum L.)

E. von SYDOW and R. BOSVIK, Swedish Institute for Preservation Research

3:40— 27. The Design of Continuous Distillation Enforcement for Volatile Fruit Aromas

NORMAN ROGER, Eastern Regional Research Laboratory, U. S. Department of Agriculture

4:00— 28. Screening Methods for Flavor Research Problems

JAMES BRODERICK, River Edge, New Jersey

4:20— 29. Determination of JND's and Thresholds in the Perception of Vanilla Flavor

RICHARD L. HALL and W. STAHL, McCormick and Co., Inc.

4:40— 30. Studies on the Volatile Fraction of Oil of Black Pepper

WALTER G. JENNINGS and R. E. WROLSTAD, University of California

5:00 p.m. Deadline—Room must be cleared.

MONDAY AFTERNOON—MAY 8

Section 2B—Gold Ball Room

Microbiology

Chairman: A. W. ANDERSON

Oregon State College

1:40— 31. Studies on the Effect of Some Preservatives on Micro-Organisms Under Different Conditions (Presented by E. von Sydow)

N. MOLIN, Swedish Institute for Food Preservation Research

2:00— 32. Studies on the Production, Recovery and Thermal Resistance of Spores of Clostridium Pasteurianum

H. M. EL-BISI, K. TSUJI, S. SOPHIANOPOULOS, and W. B. ESSELEN, Department of Food Technology, University of Massachusetts

2:15— 33. Studies on the Production, Recovery and Thermal Resistance of Spores of Clostridium Thermosaccharolyticum

H. M. EL-BISI, K. TSUJI, S. SOPHIANOPOULOS, and W. B. ESSELEN, Department of Food Technology, University of Massachusetts

2:30— 34. Chemical Events During Death of Bacterial Endospores by Moist Heat

H. M. EL-BISI, M. AMAHA, R. V. LECHOWICH, and Z. J. ORDAL, University of Massachusetts, Asahi Breweries Ltd., Continental Can Company, and University of Illinois

2:45— 35. Effect of Preservatives and Storage Temperatures on Shelf Life of Chilled Citrus Salads

N. B. RUSHING and V. J. SENN, USDA Fruit and Vegetable Products Laboratory

3:05— 36. The Effect of Temperature and Packaging Material on the Storage Life and Bacterial Flora of Ground Beef

MURRAY JAYE, R. S. KITTAKA, and Z. J. ORDAL, Department of Food Technology, University of Illinois

3:25— 37. Metabolism of Lipids During Vegetable Fermentation

MARIE L. VORBECK, L. R. MATTICK, F. A. LEE, and C. S. PEDERSON, Cornell University

3:45— 38. The Evaluation of a Direct Contact Cap Method for the Detection of Bacterial Flora on Flat Surfaces

SEYMOUR WEXLER, HAROLD GORFEIN, and WARREN LITSKY, University of Massachusetts

4:05— 39. Media for the Detection of Pectinolytic Gram Negative Bacteria Associated with the Softening of Cucumbers, Olives and Other Plant Tissues

REESE H. VAUGHN, University of California

4:25— 40. Factors Involved in the Fermentation and Curing of Vegetables

C. S. PEDERSON and MARGARET N. ALBURY, Cornell University

4:45— 41. Evidence for a Heat Injury Effect on Enterococci

R. A. GREENBERG and J. SILLIKER, Swift & Company

Preparative gas chromatography points to new standards of purity. The Megachrom's* large sample capacity, 100 times larger than that of typical analytical instruments, is a potent new tool for the research chemist. Chromatographic resolution of large volume samples, up to 20 cc, quickly and conveniently isolates workable quantities of fractions that are 99.99+% pure—so pure that they re-define established infrared standards. Infrared spectra of ultra-pure trace components now can serve to identify low ppm concentrations of flavor- and odor-causing contaminants, and trace impurities resolved from raw material inputs or finished products. ⌘ The Megachrom is a convenient means of separating and purifying the components of basic process streams for reaction studies aimed at improving process efficiency and controlling undesirable side reactions. For complete information, write us for Data File 84-4-04.

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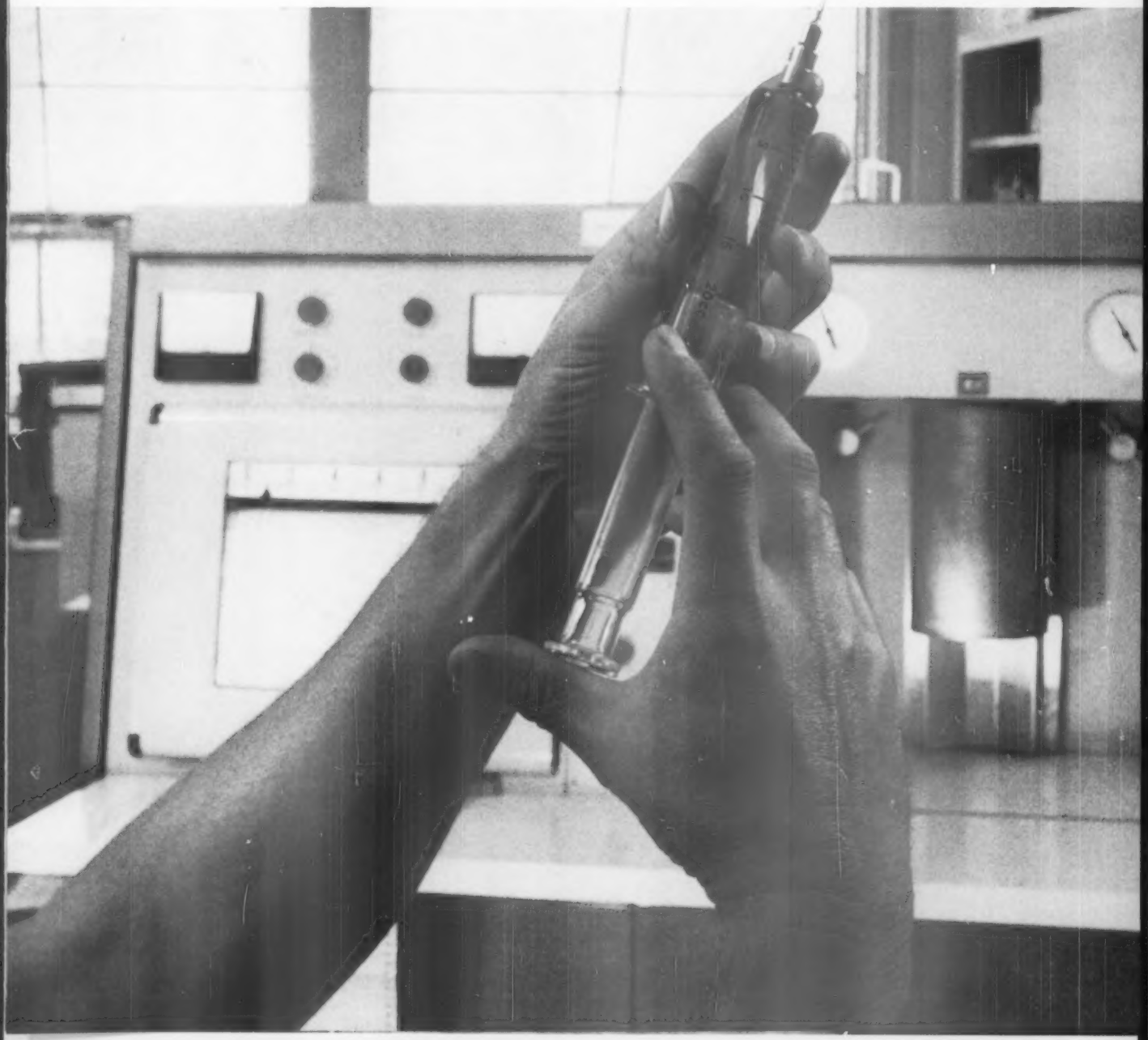

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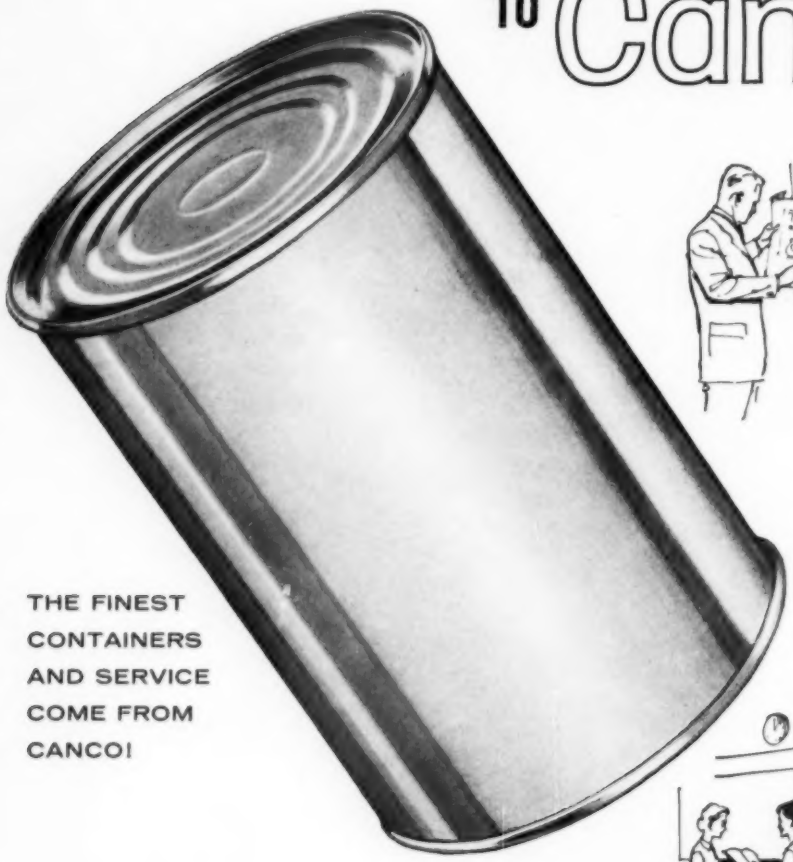

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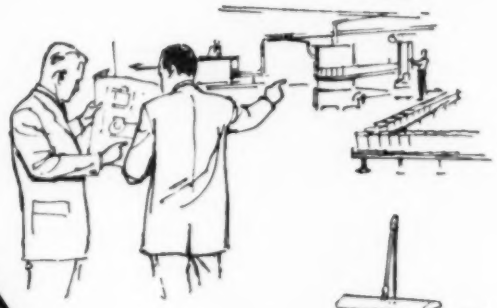

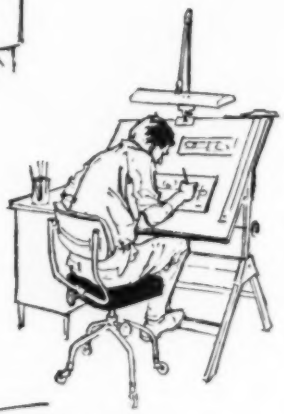

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MONDAY AFTERNOON—MAY 8

Section 2C—Skytop, 18th Floor

Dehydration

Chairman: E. SELTZER
Thomas J. Lipton, Inc.

1:40— **42.** Dehydration in Model Systems: Cellulose and Calcium Pectinate
F. SHIMAZU and C. STERLING, University of California

2:00— **43.** Coating Process for Stabilization of Dried Fruits
E. LOWE, E. L. DURKEE, W. E. HAMILTON, W. C. ROCKWELL, J. E. BREKKE, and G. G. WATTERS, Western Regional Research Laboratory

2:15— **44.** Optimum Processing Conditions for Freeze-Drying
W. R. SMITHIES, Defence Research Medical Laboratories (Canada)

2:30— **45.** Factors Influencing the Quality of Freeze-Dried Foods
W. R. SMITHIES, Defence Research Medical Laboratories (Canada)

2:40— **46.** New Continuous Production Facility for Processing "Instant" Precooked Beans
W. R. DORSEY, S. I. STRASHUN, and R. L. ROBERTS, Vacu-Dry Co.

2:55— **47.** Continuous Foam-Mat Drying
A. I. MORGAN, R. P. GRAHAM and L. F. GINNETTE, Western Regional Research Laboratory

3:10— **48.** A Method for Evaluating the Relative "Heat-Effect" of Varied Spray Drier Operating Conditions on Non-Fat Dry Milk
G. A. LUNDEEN and J. R. BRUNNER, Department of Food Science, Michigan State University

3:25— **49.** Development of a Pre-Cooked Freeze-Dehydrated Scrambled Egg Product for Military Use
L. JOKAY and R. I. MEYER, Quartermaster Food and Container Institute for the Armed Forces

3:40— **50.** Properties of Yolk-Containing Egg Solids with Added Carbohydrates
L. KLINE, J. J. MEEHAN, T. F. SUGIHARA, and HELEN L. HANSON, U. S. Department of Agriculture, WUR&DD

3:55— **51.** Moisture Absorption Characteristic of Dried Beans
ELIZABETH ELBERT, University of California

4:05— **52.** Moisture Equilibria of Dehydrated Mashed Potato Flakes
E. O. STROLLE and J. CORDING, JR., Philadelphia 28, Pennsylvania

4:20— **53.** Potato Flakelets—A New Form of Dense Flakes
R. K. ESKEW, F. H. DRAZGA, and J. CORDING, JR., U. S. Department of Agriculture, Eastern Utilization Res. Br.

4:30— **54.** Rapidly Dehydrating Vegetable Pieces by a New Process
N. H. EISENHARDT, J. CORDING, JR., and R. K. ESKEW, U. S. Department of Agriculture, Eastern Utilization Res. Br.

4:45— **55.** The Effect of Storage at Elevated Temperature on Some Proteins of Freeze-Dried Beef
L. J. N. COLE, Department of National Defence (Canada)

MONDAY AFTERNOON—MAY 8

Section 2D—West Room, Mezzanine

Fruits and Vegetables

Chairman: J. J. ALBRECHT
International Minerals & Chemical Corp.

1:40— **56.** Over- and Under-Pasteurization of Fresh Cucumber Pickles
R. C. NICHOLAS and I. J. PFLUG, Michigan State University

2:00— **57.** Development of a Method for Determining the Chemical Oxygen Demand of Pickle Manufacturing Wastes
A. L. SAARI, I. J. PFLUG, and A. TIMNICK, Michigan State University

2:15— **58.** Deterioration of Brined Cherries
G. G. WATTERS, Western Regional Research Laboratory

2:30— **59.** The Effect of Bruising on the Structure and Physical Properties of Red Cherries
M. L. BUCH and C. H. HILLS, Eastern Regional Research Laboratory

2:45— **60.** Ultramicro-Determination of Mercury in Apples
M. B. JACOBS and L. J. GOLDWATER, Columbia University

3:05— **61.** Biochemical and Physical Changes in Bananas Stored at Ambient, Optimum and Refrigerated Temperatures
KARAKIAN BEDROSIAN and AARON L. BRODY, Whirlpool Corp.

3:25— **62.** Factors Affecting the Corrosive Properties of Concentrated Tomato Products
H. H. HERNANDEZ, American Can Company

3:45— **63.** The Fatty Acids of the Lipids of Vegetables. III. Sweet Corn
F. A. LEE and L. R. MATTICK, Cornell University

4:00— **64.** Dehydroacetic Acid Treatments for Pre-Peeled Squash
F. J. FRANCIS and M. A. JIMENEZ, University of Massachusetts

4:15— **65.** Rapid Measurement of Potential Clarification and Gelation in Frozen Orange Concentrate. I.
KUANG C. LI, M. D. MARULJA, and G. H. EZELL, University of Florida

5:35— **66.** Direct Gass Chromatographic Analysis of Organic Volatiles from Foods
I. S. FAGERSON and W. W. NAWAR, University of Massachusetts

4:50— **67.** Gas Chromatography as an Objective Method of Flavor Measurement
W. W. NAWAR and I. S. FAGERSON, University of Massachusetts

TUESDAY MORNING—MAY 9

General Session

Penn Top and Skytop, 18th Floor

SYMPOSIUM

Food Science and Feeding Mankind

Chairman: P. A. BUCK
Cornell University

8:50 Introduction
W. H. SEBRELL, Columbia University

9:00— 68. Prevention of Protein Malnutrition
W. H. SEBRELL, Columbia University

9:15— 69. Atherosclerosis, Obesity and Related Problems
H. VAN ITALLIE, St. Luke's Hospital

9:30— 70. Carbohydrates, Energy and the Goal of Total Nutrition
C. G. KING, The Nutrition Foundation, Inc.

9:45— 71. Food Science in One Nation's Problem—The U.S.S.R. Food Program
F. E. DEATHERAGE, Ohio State University

10:00— 72. Problems of Applying Food Technology in Undeveloped Countries
Z. I. KERTESZ, Cornell University

10:15— 73. How Will Food Science Meet Future Needs?
B. L. OSER, Food & Drug Research Laboratories, Inc.

10:30 Recess

10:40 Panel Discussion and Questions
Moderator—W. H. SEBRELL, Columbia University

11:45 Summary
C. G. KING, The Nutrition Foundation, Inc.

TUESDAY AFTERNOON—MAY 9

General Session

Penn Top, 18th Floor

Chairman: I. J. HUTCHINGS
President, I.F.T.

1:30 Babcock-Hart Award Address

TUESDAY AFTERNOON—MAY 9

Section 4A—Penn Top, 18th Floor

SYMPOSIUM

Food Additives

Chairman: J. F. MAHONEY
Merck & Co., Inc.

2:20— 74. Introductory Remarks
JOHN F. MAHONEY, Merck & Co., Inc.
(Chairman, I.F.T. Committee on Food Additives and Components)

2:30— 75. The Impact of the Food Additives Amendment on Analytical Laboratory Operations
KENNETH MORGAREIDGE, Food and Drug Research Laboratories, Inc.

2:50— 76. Food Colors and the New Color Additives Amendment
SAMUEL ZUCKERMAN, H. Kohnstamm & Co., Inc.

3:10— 77. What the Food Technologist Should Know About Safety Evaluations and Toxicity Testing
LLOYD HAZLETON, Hazleton Laboratories, Inc.

3:30— 78. Food Additives Amendment—Impact on the Food Processor
B. F. DAUBERT, General Foods Corporation

3:50— 79. Current Aspects of the Food Additives Amendment
L. M. BEACHAM, Food and Drug Administration

4:10— 80. Recent Progress in the Consideration of Flavoring Ingredients under the Food Additives Amendment. II.
RICHARD L. HALL, McCormick & Co., Inc.

4:25 Question and Answer Period with Speakers as Panelists

TUESDAY AFTERNOON—MAY 9

Section 4B—Gold Ball Room

Fruits and Vegetables—Quality Aspects

Chairman: A. KRAMER
University of Maryland

2:20— 81. Colorimetry of Cranberry Sauce
G. J. SERVADIO and F. J. FRANCIS, University of Massachusetts

2:40— 82. Relationship of Peach Maturity to Color Grade After Canning
S. LEONARD, B. S. LUH, C. O. CHICHESTER, and L. L. CLAYPOOL, University of California

3:00— 83. A Method for Pigment Determination in Processed Spinach
T. C. TAN and F. J. FRANCIS, University of Massachusetts

3:20— 84. Low Temperature Handling of Sterilized Foods. IV. Color, pH and Flavor Evaluations of Canned Vegetables
F. M. JOFFE, L. L. GUSTAFSON, and C. O. BALL, Rutgers University

3:40— 85. Low Temperature Handling of Sterilized Foods. VI. Color, pH and Flavor Evaluations of Canned Soups, Tomato Juice, and Evaporated Milk
F. M. JOFFE, DELORES C. BONGOLAN, C. O. BALL, Rutgers University

4:00— 86. Adjusting the Consistency of Applesauce
R. L. LaBELLE, C. E. KUNZ, W. B. ROBINSON, Cornell University

4:20— 87. Quality of Frozen Vegetables Purchased in Selected Retail Markets
J. P. SWEENEY, V. J. CHAPMAN, M. B. MARTIN, P. L. KING, and E. H. DAWSON, U.S.D.A., Institute of Home Economics

4:40— 88. The Spectro-Photometric Evaluation of Anthocyanin Pigment Development and Condition of Scald in Red Tart Cherries
J. B. YEATMAN, G. S. BIRTH, JANE V. ERNEST, R. L. BENDER, and A. P. SIDWELL, United States Department of Agriculture

TUESDAY AFTERNOON—MAY 9

Section 4Ca—Skytop, 18th Floor

Pressurized Food Products

Chairman: J. M. JACKSON
American Can Company

This session was arranged with the cooperation of the Aerosol Division, Chemical Specialties Manufacturers Association.

2:20— 89. Food Aerosols with Freon C-318 and Nitrous Oxide
PATRICIA A. LYCHALK and FRANK A. BOWER, Air Reduction Company, and Freon Products Division, E. I. duPont de Nemours and Company

2:40— 90. Aerosol Food Products in the FP Container
P. W. HARDY, H. T. HOFFMAN, JR., E. WHEATON, American Can Company

3:00— 91. The Formulation of Self Agitating Pressurized Food Products
J. J. SCIARRA, St. John's University

3:20— 92. Aerosol Valves for Pressurized Foods
W. E. GRAHAM, Clayton Corporation

3:40 Discussion

TUESDAY AFTERNOON—MAY 9

Section 4Cb—Skytop, 18th Floor

Packaging Food Products

Chairman: J. M. JACKSON
American Can Company

4:00— 93. Packaging of Dehydrated and Frozen Foods
O. R. JOHNSON and G. A. PITMAN, Western Waxide Division, Crown Zellerbach Company

4:20— 94. Packaging of Space Foods
D. BROWN and H. W. ADAMS, Food Machinery and Chemical Corporation

4:40— 95. Factors Affecting Color of Packaged Retail Beef Cuts in Storage
D. A. FELLERS, I. J. WAHBA, and C. O. BALL, Rutgers University

TUESDAY AFTERNOON—MAY 9

Section 4D—West Room, Mezzanine

Meat and Fish—Structure and Texture

Chairman: B. F. DAUBERT
General Foods Corporation

2:20— 96. Biochemistry of Pork Muscle Structure. I. Rate of Anaerobic Glycolysis and Temperature Change Versus the Apparent Structure of Muscle Tissue
E. J. BRISKEY and J. WISMER-PEDERSEN, The University of Wisconsin

2:40— 97. Biochemistry of Pork Muscle Structure. II. Preliminary Observations of Biopsy Samples Versus Ultimate Muscle Structure
E. J. BRISKEY and J. WISMER-PEDERSEN, The University of Wisconsin

2:55— 98. Some Relations Between the Chemical and Physical Characteristics of Bovine Muscles
C. LOCKETT, C. E. SWIFT, and W. L. SULZBACHER, U. S. Department of Agriculture, Eastern Regional Research Laboratory

3:15— 99. Comminuted Meat Emulsions: The Capacity of Meats for Emulsifying Fat
C. E. SWIFT, C. LOCKETT, and A. J. FRYAR, U. S. Department of Agriculture, Eastern Regional Research Laboratory

3:30—100. Sonic Tenderization of Beef
N. B. WEBB, L. J. BRATZLER, and W. T. MAGEE, Michigan State University

3:50—101. Relation of Backfat Thickness on Hog Carcasses to Physical, Chemical and Sensory Evaluations of Pork Loin Quality
LUZ U. ONATE and AGNES FRANCES CARLIN, Iowa State University

4:05—102. Interrelationship of Various Post-Mortem Changes with Tenderness of Chicken and Pork
K. N. MAY, R. L. SAFFLE, D. L. DOWNING, and JOHN J. POWERS, University of Georgia

4:25—103. Application of Centrifugal Method for Measuring Shrinkage During the Thawing and Heating of Frozen Cod Fillets
DAVID MIYAUCHI, U. S. Department of Interior, Fish and Wildlife Service

4:45—104. Development of an Instrument for Texture Evaluation of Fishery Products
J. A. DASSOW, L. G. McKEE, and R. W. NELSON, U. S. Department of Interior, Fish and Wildlife Service

WEDNESDAY MORNING—MAY 10

Section 5A—Grand Ball Room, Mezzanine

Colors and Flavors

Chairman: J. H. MCGLUMPHY
International Flavors & Fragrances, Inc.

8:40—105. Onion Flavor Constituents and Precursors
J. F. CARSON, F. F. WONG, and S. SCHWIMMER, Western Regional Research Laboratory

9:00—106. Enzymological Basis of Flavor Development in Onions
S. SCHWIMMER, M. MAZELIS, and J. F. CARSON, Western Regional Research Laboratory

9:20—107. Isolation and Identification of Chemical Compounds Responsible for a Defect in Sauerkraut
MARIE L. VORBECK, L. R. MATTICK, F. A. LEE, and C. S. PEDERSON, Cornell University

9:40—108. Isolation of Steam Volatile Flavor Components from Peas
J. F. CARSON, E. J. BARTA, P. W. KILPATRICK, and J. W. RALLS, Western Regional Research Laboratory

10:00—109. Characterization of Off Flavors in Benzene Hexachloride Treated Carrots
ANDRÉ BOLAFFI, ROY E. MORSE, ELIZABETH F. STIER, Rutgers University

10:20—110. Volatile Organic Acids of Bread

I. R. HUNTER, H. NG, and J. W. PENCE, Western Regional Research Laboratory

10:40—111. Imparting Yeast Leavened Flavor and Aroma to Baked Goods

SIMON JACKEL and ELEANOR ERSOY, Vico Products Company

11:00—112. Methods of Analysis of Encapsulated Substances

ROBERT T. MALEENY, Dodge and Olcott, Inc.

11:20—113. B-Apo-8′-Carotenal, a New Food Color

J. C. BAUERNFEIND and R. H. BUNNELL, Hoffmann-La Roche, Inc.

11:40—114. Certified F. D. & C. Lake Colors for Foods

SAMUEL ZUCKERMAN, H. Kohnstamm and Co., Inc.

WEDNESDAY MORNING—MAY 10

Section 5B—Gold Ball Room

General Research

Chairman: P. E. RAMSTAD

General Mills, Inc.

8:40—115. Effect of Syrup Composition on Sweetness and Acceptability of Canned Clingstone Peaches

W. J. HOOVER, Corn Indus. Research Foundation

9:00—116. Vitamin K_5 as a Food Preservative: 1. Fruit Juices

H. Y. YANG, Oregon State Colllege

9:20—117. Protein Rich Food Problems in Developing Countries

M. MILNER, United Nations Children's Fund

9:40—118. Studies to Improve the Quality of Reconstituted Milk Cheese—I

I. I. PETERS and J. WILLIAMS, Texas Agricultural and Mechanical College

10:00—119. The Effect of Copper and Iron on the Oxidative Flavor Deterioration of Ice Cream

C. VANDERZANT and M. H. MIAH, Texas Agricultural Experiment Station

10:20—120. Microcrystalline Cellulose: A New Food Product Development

C. T. HERALD, American Viscose Corporation

10:40—121. The Diffusion of Oligosaccharides

MALCOLM C. BOURNE, C. O. CHICHESTER, C. STERLING, University of California

11:00—122. An Investigation of Varietal Differences in the Iodine-Binding Capacities of Crystalline Rice Amyloses

VIRGINIA R. WILLIAMS, Louisiana State University

11:20—123. Parboiling Characteristics of California Medium-Grain Rice

D. K. MECHAM, E. B. KESTER, and J. W. PENCE, Western Regional Research Laboratory

11:40—124. Cooking Losses, Acceptability, and Cost Per Serving of U. S. Grade A, B, and C Turkey Hens

GRAYCE E. GOERTZ and BARBARA L. WEATHERS, Kansas State College

WEDNESDAY MORNING—MAY 10

Section 5C—Skytop, 18th Floor

SYMPOSIUM

Statistical Quality Control

Moderator: B. A. FILICE

Filice & Perrelli Co.

(Chairman, I.F.T. Committee on Quality Control of Food Products)

8:40—125. Use of Statistical Programs from the Consumer's Viewpoint

R. N. JOHNSON, The Kroger Co.

9:00—126. An Operations Research Study of a Quality Control Problem in the Meat Industry

W. GOLOMSKI, H. J. Mayer & Sons

9:20—127. Procedures for Study of Raw Product Quality Attributes and Programming the Complex Analysis on a Computer

G. ROWE, University of California

9:40—128. Application of Results of a Raw Product Sampling Program to Cannery Operations for Improved Processed Product Quality

A. MITTLER, California Packing Corp.

10:00—129. Use of the California Weights and Measures Code

HENRY CONDEN, Safeway Stores

10:20—130. Application of Statistical Methods to the Development of a Standard of Identity for Shucked Oysters

A. KRAMER, University of Maryland

10:40 Discussion—Questions

B. A. FILICE, Moderator; S. J. HOTCHNER, Secretary, Filice & Perelli and American Can Co.

WEDNESDAY MORNING—MAY 10

Section 5D—West Room, Mezzanine

Pigments and Lipids in Animal Products

Chairman: H. S. OLCOTT

University of California

8:40—131. The Browning Produced on Cooking Fresh Pork. I. The Relation of Intensity of Browning to Chemical Constituents and pH

A. M. PEARSON, G. HARRINGTON, R. G. WEST, and E. M. SPOONER, Michigan State University

9:00—132. The Browning Produced on Cooking Fresh Pork. II. The Nature of the Reaction

A. M. PEARSON, B. G. TARLADGIS, and E. M. SPOONER, Michigan State University

9:20—133. Fractionation of the Components Responsible for Sex Odor in Pork

H. B. CRAIG, A. M. PEARSON, and N. B. WEBB, Michigan State University

9:40—134. Spectrophotometric Estimation of Metmyoglobin in Frozen Meat Extracts

J. P. LANE and L. J. BRATZLER, Michigan State University

10:00—135. Factors Effecting the Autooxidation of Myoglobin

HARRY E. SNYDER, Iowa State University

10:20—136. Utilization of Gentisic Acid and Sodium Gentisate as Water-Soluble Antioxidants
THEODORE WISHNETSKY, Eastman Chemical Products, Inc.

10:40—137. Purification and Determination of the 2-Thiobarbituric Acid-Malonaldehyde Pigment in Rancid Foods
T. C. YU and R. O. SINNHUBER, Oregon State College

11:00—138. Fatty Acid Composition of Meat Tissue Lipids
I. HORNSTEIN, P. F. CROWE, and M. J. HEIMBERG, U. S. Department of Agriculture, Eastern Regional Research Laboratory

11:20—139. Oxidative Rancidity in Cooked Mullet
MARELYNN W. ZIPSER and BETTY M. WATTS, Florida State University

11:40—140. Lipid and Ascorbic Acid Oxidation in Milk and Model Systems
G. J. SMITH and W. L. DUNKLEY, University of California

WEDNESDAY AFTERNOON—MAY 10

General Session

Grand Ball Room, Mezzanine

Chairman: I. J. HUTCHINGS
President, I.F.T.

1:30 Nicholas Appert Award Address

2:10 Business Meeting

WEDNESDAY AFTERNOON—MAY 10

Section 6A—Grand Ball Room, Mezzanine

SYMPOSIUM

Education of a Food Technologist

Moderator: R. E. MORSE
Thomas J. Lipton, Inc.

2:40—141. Past, Present and Future Activities of the Committee on Education
R. M. SCHAFFNER, Libby, McNeill and Libby

2:55—142. Value of Graduate Training for Food Technologists Employed by Industry
G. STEWART, University of California

3:10—143. The Need for Undergraduate Training
R. T. MILNER, University of Illinois

3:25—144. The Need for Graduate Training
B. SCHWEIGERT, Michigan State University

3:40—145. Educating the Food Technologist in Europe
FROEDE BRAMSNAES, Fiskeriministeriets Forsøglaboratorium, Copenhagen K (Denmark)

3:55—146. The Role of Industry, The University and the I.F.T. in the Training of Food Technologists
R. B. WAKEFIELD, Gerber Products Co.

4:10—147. The Food Scientist of Tomorrow
D. DeFELICE, General Foods Corp.

4:25—148. The Food Technologist and the Market Place
C. FELDBERG, Chas. Pfizer & Co., Inc.

4:40 Discussion

WEDNESDAY AFTERNOON—MAY 10

Section 6B—Gold Ball Room

Microbiology—Radiation

Chairman: H. E. GORESLINE
Quartermaster Food and Container Institute for the Armed Forces

2:40—149. The Effect of Radiation Environment on the Thermal Resistance of Irradiated Spores of Cl. Sporogenes P.A. 3679
J. J. LICCIARDELLO, Massachusetts Institute of Technology

3:00—150. A Study of the Radiation Resistance of a Marine Pseudomonas Sp.
E. von SYDOW and J. TEAR, Swedish Institute for Food Preservation Research

3:25—151. The Effect of Additives on the Survival of Clostridium Botulinum Subjected to Gamma Irradiation
A. W. ANDERSON, Oregon State College

3:40—152. Growth Support Potential of Irradiated Chicken for Escherichia Coli and Staphylococcus Aureus
M. SOLBERG and J. T. R. NICKERSON, Colonial Provision Company, Inc.

3:55—153. Irradiation Pasteurization of Shrimp and Crabmeat
R. O. SINNHUBER, Oregon State College

4:10—154. A Biological After-Effect in Radiation Processed Chicken Muscle
M. SOLBERG and J. T. R. NICKERSON, Colonial Provision Company, Inc.

4:25—155. Relation of Gamma Ray Emission to the Lean Content of Beef Rounds
R. KULWICH, L. FEINSTEIN, C. GOLUMBIC, W. R. SEYMOUR, W. R. KAUFFMAN, and R. L. HINER, U. S. Department of Agriculture

4:40—156. Effect of Moisture Level on the Development of Irradiation Flavor in Partially Dehydrated Irradiated Pork
J. E. THOMPSON, D. B. PERYAM, E. KARMAS, and H. E. WISTREICH, Reliable Packing Company

WEDNESDAY AFTERNOON—MAY 10

Section 6Ca—Skytop, 18th Floor

Statistical Techniques

Chairman: B. A. FILICE
Filice & Perrelli Co.

2:40—157. Some Nonparametric Statistics Applied in Taste Testing
J. N. EISEN, U.S.D.A. Human Nutrition Research Div.

3:00—158. Experimental Designs to Measure Flavor Differences with Special Reference to Clingstone Peaches
W. J. HOOVER, Corn Indus. Res. Foundation

3:20—159. Single and Paired Samples in Household Consumer Testing
MARION SIMONE, University of California

WEDNESDAY AFTERNOON—MAY 10

Section 6Cb—Skytop, 18th Floor

Process Engineering—Instrumentation

Chairman: J. B. ANDERSON
H. J. Heinz Company

3:45—160. Programming Clean-In-Place (C.I.P.) Systems
E. K. KUHLES, Tri-Clover Division of Ladish Company

4:05—161. Instrumental Aspects of Food Analysis by Gas Chromatography
W. AVERILL, The Perkin-Elmer Corporation

4:25—162. Automatic Process Programming and Computing in the Food Industry
W. S. TAYLOR, Minneapolis Honeywell Regulator Company

4:45 Discussion

WEDNESDAY AFTERNOON—MAY 10

Section 6D—West Room, Mezzanine

Meat and Fish—Bacterial and General

Chairman: M. E. STANSBY
U. S. Bureau of Commercial Fisheries

2:40—163. A Study of Three Rapid Methods for Detecting Spoilage in Meat
R. L. SAFFLE, K. N. MAY, H. A. HAMID, and J. D. IRBY, University of Georgia

3:00—164. Shelf-Life and Bacterial Counts of Excised Poultry Tissues
K. N. MAY, J. D. IRBY, and JAMES L. CARMON, University of Georgia

3:20—165. Standards Development Program at the Gloucester Tech. Lab. of the Bureau of Commercial Fisheries
ANTHONY FRASCATORE, JOHN RYAN, RICHARD TENNEY, and JOSEPH CARVER, U. S. Dept. of Interior, Fish and Wildlife Service, Gloucester, Mass.

3:40—166. Composition of Commercially Important Fish Taken from New England Waters
RICHARD BROOKE and MAYNARD STEINBERG, U. S. Dept. of Interior, Fish and Wildlife Service, Gloucester, Mass.

4:00—167. The Proximate Composition of Four Commercially Important Bottom Fish
C. E. THURSTON, Bureau of Commercial Fisheries, U. S. Dept. of Interior, Seattle, Wash.

4:20—168. A Comparison of Objective Tests and Subjective Evaluations of Quality of Shrimp
MARY E. AMBROSE, C. F. LEE, and F. T. PISKUR, U. S. Dept. of Interior, Fish and Wildlife Service, College Park, Maryland

4:40—169. Tritiated Water for Measuring Fluid Transfer in Oysters
E. A. FIEGER, A. F. NOVAK, and W. T. BURNETT, JR., Agricultural and Mechanical College, Louisiana State University

Advice to IFT Speakers!

Some years ago someone asked Somerset Maugham for advice for would-be authors. His answer: "Stick to the point, and cut, cut, cut."

This dictum, applied ruthlessly, will wound egos right and left, and may discourage the faint-hearted from even trying. But the advice is good.

The food scientist is, willy-nilly, an author. And, having no hope of entertaining but being bound to inform, he most particularly must heed this rule.

Advice very like this is proffered by the Biochemical Society of London, in a mimeographed commentary "Notes on the Presentation of Papers at the Society's Meetings."

Briefly, the Society's advice is:

1) Stick closely to the time allotted if you don't want the chairman to cut you off. Rehearse your speech. Take whatever steps you must to provide a margin of 1–2 minutes. This fosters your popularity and intelligent discussion from the floors.

2) If possible, DO NOT READ your manuscript. Know your material, and make it sound extemporaneous.

3) Do not show more than 3 slides in 5 minutes of speaking time. Slides must be INTELLIGIBLE even to those who cannot hear what you are saying. They must be properly marked, not overcrowded, and, of course, LEGIBLE. Don't show photographs of tables from published papers. They are seldom clear enough, and usually contain more than can be absorbed during a speech. If abbreviations must be used, explain them.

4) When showing slides talk to the audience, not the screen. If the slides need comment, have a copy in front of you. Use a pointer only a minimum. Remember, you are not transparent.

5) Time is precious. Some formalities may be omitted or pared ruthlessly: a. all but the briefest historical introduction; b, bibliographical references, except names of authors; c. spoken acknowledgments to colleagues, assistants, or benefactors (except barest essentials).

6) Be loud and clear all the way to the back of the hall.

These suggestions should become law for scientific meetings.

G. F. STEWART

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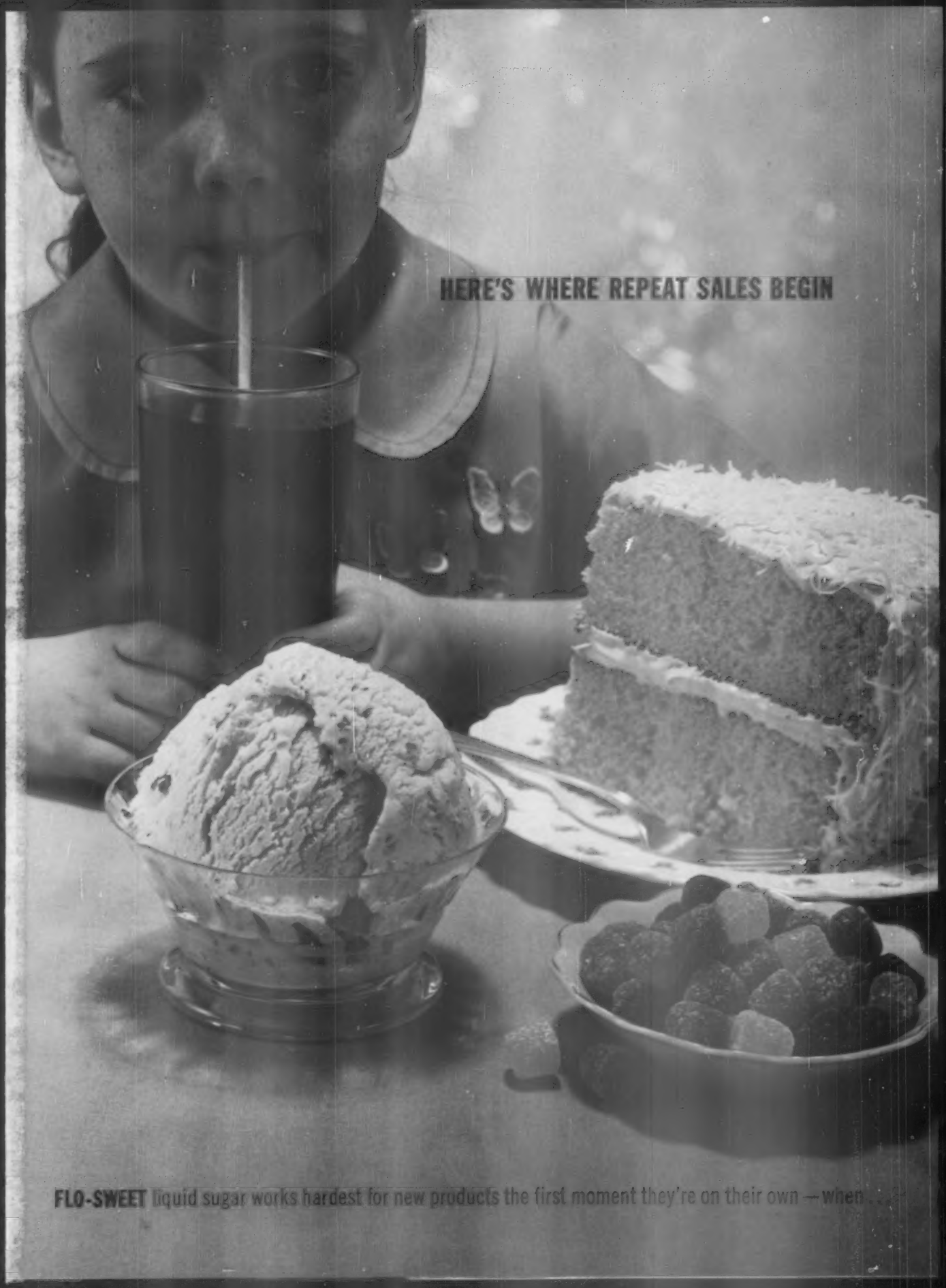
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The Effect of Vacuum Packaging on Some Sliced Processed Meat Products as Judged by Organoleptic and Bacteriologic Analysis

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Swedish Institute for Food Preservation Research

(Manuscript received September 14, 1960)

SUMMARY

Some sliced processed meat products were shown to retain higher quality in cold storage when vacuum-packed (3 mm Hg) in heat-sealed Cellophane polyethylene bags than when sealed at atmospheric pressure. Appearance, organoleptic acceptability, and bacterial growth were used as criteria for quality. The microflora changed in vacuum-packed samples from a mixed population of *Bacillus* sp., *Achromobacter* sp., and *Lactobacillus* sp. to an almost pure culture of *Lactobacillus* sp. or *Achromobacter* sp. during storage. No qualitative changes were observed in corresponding samples sealed at atmospheric pressure.

If the time to reach a certain viable count is taken as a measure of the ability of the product to keep its quality, one can draw the conclusion that the prolonging of shelf-life in vacuum-packaging is greater when the initial bacterial count is low. Slower growth and changed metabolic activity of the present microorganisms might explain the higher quality of the vacuum-packed samples under the experimental conditions employed.

VACUUM PACKAGING of sliced meat is used increasingly in Sweden, as in many other European countries. This method makes packing and distribution more rational, for the meat products can be sliced and packed at the factory. Also, vacuum-packed cured meat is claimed to have better quality than meat packed at atmospheric pressure. First, the natural color resists change better, for the changes in color of cured meat products are essentially dependent on oxygen. Also, oxidative rancidity is dependent on oxygen, and therefore is checked when the oxygen is depleted from the packages.

Lowering the pressure of oxygen at the moment of heat-sealing can also be expected to influence the growth of the associated microorganisms, and thereby the keeping quality from a bacteriological and organoleptic point of view. However, this has been questioned by some research workers dealing with the subject. Thus, Leistner (1956, 1957) found a certain checking and a qualitative change of the microflora in vacuum-packed meat products, but the differences were small and, in his opinion, insignificant from the commercial point of view. Linderholm (1960), who investigated the keeping quality of vacuum-packed sliced meat products on the Swedish market, found no difference in total bacterial counts between stored vacuum-packed and non-vacuum-packed products. He claims that a better bacteriological quality should not be pointed out as an essential advantage of vacuum packaging. In contrast, considerable differences between total bacterial counts in vacuum-packed and non-vacuum-packed ground lamb was reported by Halleck *et al.* (1958b). Brown and Schmucker (1960), working with bacon, also noticed clear differences between vacuum-packed and non-vacuum-packed samples stored at 28–32°F (−2.2–0°C). Qualitative changes in the microflora were also reported by Allen and Foster (1960), who found a dominance of *Lactobacillus* sp. in vacuum-packed sliced meat.

The problem in these experiments was to elucidate the effect of vacuum packaging on the keeping quality of some meat products, judged by organoleptic and bacteriologic analysis. The growth rate in vacuum-packed and non-vacuum-packed samples was tested at different storage temperatures. The significance of the number of microorganisms at the time of packing

was investigated. It was also of interest to gain information on any possible qualitative changes in the microflora of vacuum-sealed samples compared with non-vacuum-sealed samples.

EXPERIMENTAL

Organoleptic examination. The meat products were cut into slices and put into Cellophane polyethylene bags. One part was heat-sealed at atmospheric pressure and the other part at a pressure of 3 mm Hg. The vacuum-sealing apparatus used was constructed and described by Bosvik (1960). The apparatus had a high-capacity vacuum pump that could give a sealing pressure of 3 mm Hg. All bags were pressed between sponge-rubber plates in the apparatus immediately before sealing, thus giving a small gas volume in each pack.

In the first experiment the meats were wieners, salt-cured meat, and German sausage (a bologna-type) stored at −1.5, 0, +3, +6 and +15°C. Samples were examined at intervals, and the storage time determined when sour smell could be noticed. The result showed that sour smell could be traced earlier in non-vacuum-packed samples for all types of meat products investigated, and at all storage temperatures (Table 1).

In the next experiment odor and appearance were judged on a 5-degree scale. Highest score was assigned to the fresh product. The meat products and storage temperatures were the same as in the first experiment. The result showed that off-flavor could be noticed earlier in samples packed at atmospheric pressure than in vacuum-sealed samples. It might be pointed out that off-flavors, especially at higher storage temperatures, can be noticed at an earlier stage than changes in appearance. The samples were, however, stored in darkness.

In Fig. 1a and 1b the average score for odor and appearance, respectively, during 14 days' storage, is plotted against the storage temperature for vacuum-sealed samples and for samples sealed at atmospheric pressure. The vacuum-packed samples have a higher average score for both odor and appearance at all temperatures tested. The differences between vacuum- and non-vacuum-packed samples are especially significant for salt-cured meat.

Bacteriological examination. Total bacterial counts in the samples were determined by plating on tryptone-glucose agar with the addition of bromcresol purple as an indicator. The bacterial counts given are usually the average of 4 samples. The samples were homogenized in 100 ml of sterile water for 30 seconds in a homogenizer. Adequate dilutions were made and mixed with 15 ml agar. The plates were incubated 4 days at 20°C before being counted.

Experimental series I. Sliced salt-cured meat, sliced German sausage, and wieners were vacuum-packed, and the numbers of bacteria/g in the vacuum-packed samples were compared with those in samples sealed at atmospheric pressure. Examinations were carried out at different times and storage temperatures. The results are in Table 2. It appears that the total number of bacteria in practically all cases is lower in the vacuum-packed samples than in corresponding samples sealed at atmospheric pressure. In Fig. 2, the time required for a sample of German sausage to reach a bacterial count of 10^6/g is plotted against storage temperature for vacuum-packed samples as well as for samples sealed at atmospheric pressure. The times in the respective cases are estimated from the growth curves. Significant differences between vacuum and non-vacuum were noticed at all experimental temperatures, except at −1.5°C. In the experiment demonstrated in Fig. 2, initial infection was about 20,000 bacteria/g.

Table 1. Storage periods (days) for processed vacuum-packed and non-vacuum-packed meats until detection of sour smell at different temperatures.

Storage temp. (°C)	Wieners		Salt-cured meat		German sausage	
	3 mm Hg	Atm.	3 mm Hg	Atm.	3 mm Hg	Atm.
−1.5	>21	>21	>21	>21	>21	14
0	>21	>21	>21	7	>21	12
3	>21	15	>21	4	14	4
6	14	6	>21	4	8	4
15	6	2	6	2	2	2

Table 2. Logarithm of bacterial counts under different storage conditions and times (days) for wieners, salt-cured meat, and German sausage.

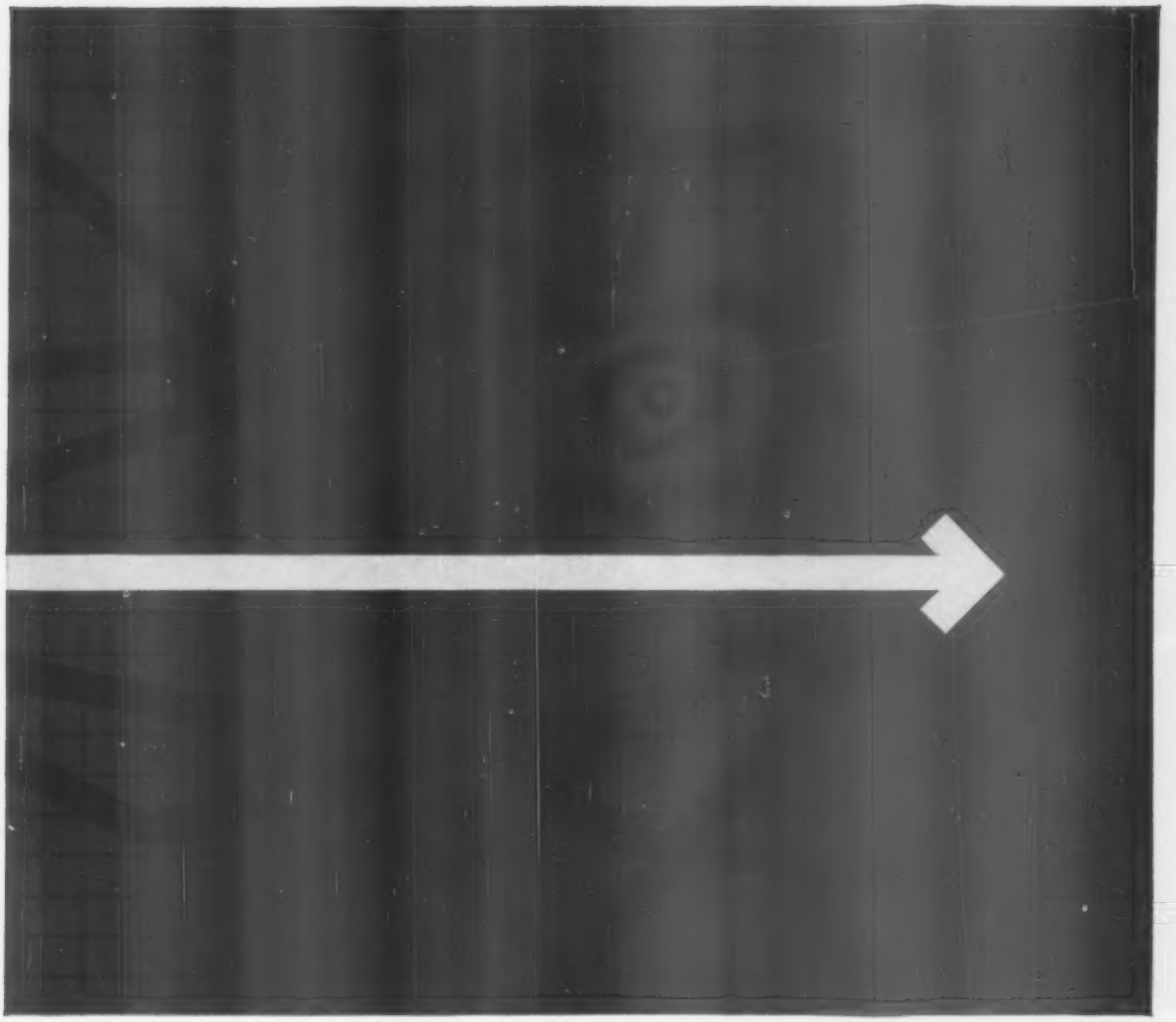
Temp.	0°C		3°C		6°C		15°C	
	3 mm Hg	Atm.	3 mm Hg	Atm.	3 mm Hg	Atm.	3 mm Hg	Atm.
(days)								
Wieners								
0	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
2					4.4	4.3	6.8	7.0
3	4.2		4.5	4.4				
4					4.6	4.4	8.0	8.2
5	4.4	4.1	4.5	4.7				
7					5.0	5.1	8.5	8.5
8		4.4	5.4	5.6				
9					7.4	6.7		8.5
10	4.7	4.8	6.2					
14	4.9		7.2	7.7	7.8	7.9	8.5	8.7
21	5.9	6.3	7.8	7.2				
Salt-cured meat								
0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
2					5.2	5.7	7.9	8.0
3	4.7	4.6	4.9	4.8				
4					5.1	7.1	7.9	8.7
6	5.0	5.4	5.1	6.6				
7					5.3	7.4	8.0	8.8
10	5.3	5.7	6.6	7.0				
13					6.4	7.9	7.8	10.0
14	5.9	5.9	6.9	8.7				
21	6.6	7.4	7.2	8.0				
German sausage								
0	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4
2					5.0	5.8	6.4	6.9
3	4.9	5.0	5.4	5.6				
4					5.7	6.6	7.7	8.0
5	5.0	5.1	5.2	6.9				
7					6.8	7.0	8.0	8.2
10	5.9	6.9	6.8	8.1				
14					7.2	8.4	8.2	7.6
21	6.7	7.8	8.0	8.3				

Experimental series II. To obtain better-defined experimental conditions these series and the following ones were carried out with a sausage produced at our laboratory the day before the experiments were started. The sausage had the following composition: 4.3 kg veal meat, 3.0 kg pork meat, 1 kg lard, and 150 g NaCl. Neither nitrate nor nitrite was added. The veal and pork meats were mixed in a chopper during 5 minutes. Five kg of this mixture was removed, and the rest mixed for 5 minutes with the lard and the salt. The mixture was stuffed firmly in artificial sausage casings, and the sausages thus produced were kept in a water bath at 80°C for 45 minutes, followed by storage at 0°C for 20 hours. The sausages were then sliced and packed.

The following experimental sections were included in the experiment: sausage slices dipped in: a) sterile water, b) a suspension of *Bacillus* sp., c) a suspension of *Achromobacter* sp., d) a homogenized suspension of vacuum-packed sausage, high in bacterial count. Half of the samples in each experimental section were heat-sealed at 3 mm Hg, the other half at atmospheric pressure. Slicing and sealing were carried out at room temperature, but none of the samples was kept at this temperature for more than 30 minutes. At the start, 3 samples were taken from each experimental section for bacteriological analysis. The rest was incubated at +5°C in darkness.

Bacterial counts were made at intervals on tryptone-glucose agar. Even in these experiments there was a clear indication that the microorganisms were developing more slowly in vacuum-sealed bags than in samples sealed at atmospheric pressure (Table 3).

Experimental series III. In this experiment, packages of sausage both vacuum-packed and non-vacuum-packed were stored at 0, +3, +5, and +15°C. The sausage used contained about 500 organisms per g. Samples were taken at different intervals, depending on storage temperature. The results (Fig. 3) show a significant difference in bacterial growth between packages sealed at 3 mm Hg and atmospheric pressure. The



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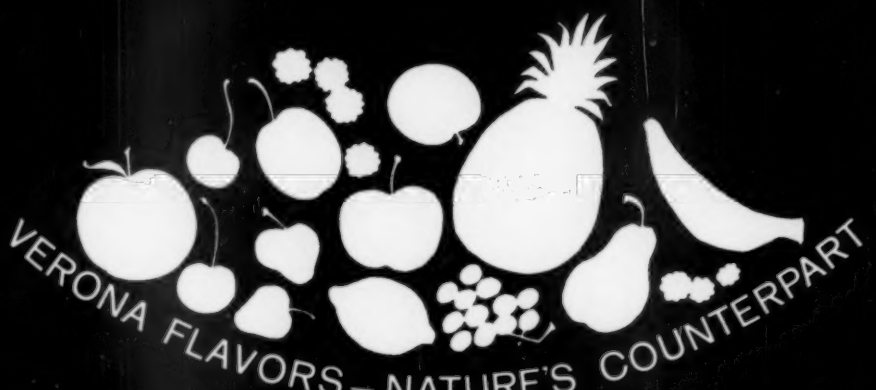

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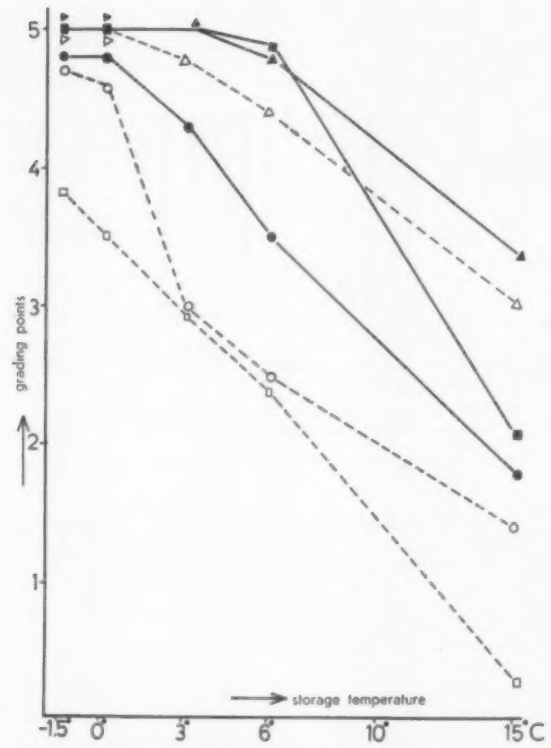

Fig. 1a. The average score for odor during 14 days of storage at different temperatures.

■ ——— ■ sliced salt-cured meat, sealed at 3 mm Hg.
□ - - - - □ sliced salt-cured meat, sealed at atmospheric pressure.
● ——— ● sliced German sausage, sealed at 3 mm Hg.
○ - - - - ○ sliced German sausage, sealed at atmospheric pressure.
▲ ——— ▲ wieners, sealed at 3 mm Hg.
△ - - - - △ wieners, sealed at atmospheric pressure.

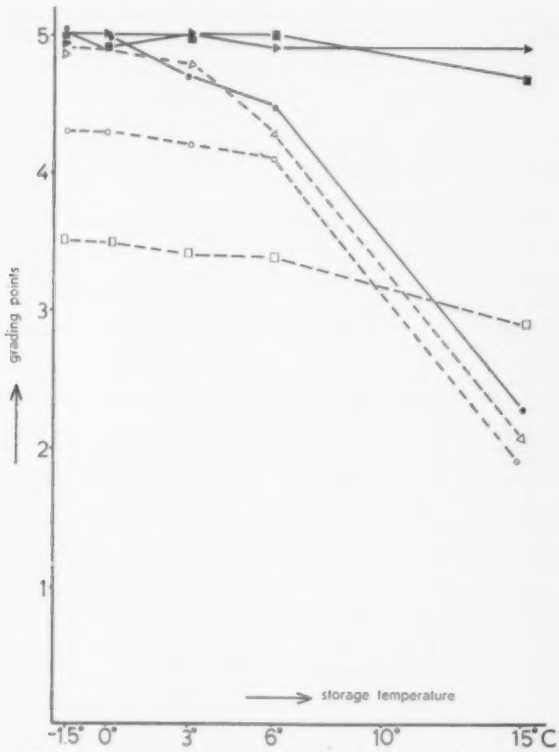

Fig. 1b. The average score for appearance during 14 days of storage at different temperatures.

■ ——— ■ sliced salt-cured meat, sealed at 3 mm Hg.
□ - - - - □ sliced salt-cured meat, sealed at atmospheric pressure.
● ——— ● sliced German sausage, sealed at 3 mm Hg.
○ - - - - ○ sliced German sausage, sealed at atmospheric pressure.
▲ ——— ▲ wieners, sealed at 3 mm Hg.
△ - - - - △ wieners, sealed at atmospheric pressure.

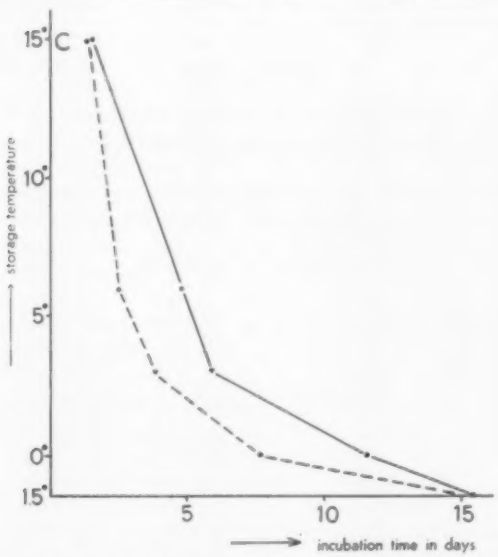

Fig. 2. Calculated time required for a sample of German sausage to reach a bacterial count of 10^7 organisms per gram at different storage temperatures.

——— sealed at 3 mm Hg.
- - - - sealed at atmospheric pressure.

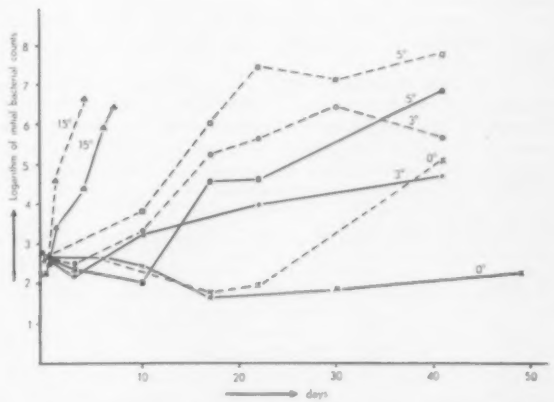

Fig. 3. Bacterial growth at different storage temperatures in samples sealed at 3 mm Hg and atmospheric pressure.

——— sealed at 3 mm Hg.
- - - - sealed at atmospheric pressure.

Table 3. Bacterial counts in vacuum-packed and non-vacuum-packed samples inoculated with different organisms at the time of packaging.

	Log bacterial counts							
	a		b		c		d	
Days at 5°C	3 mm Hg	Atm.	3 mm Hg	Atm.	3 mm Hg	Atm.	3 mm Hg	Atm.
0	2.6	2.6	3.8	3.1	3.1	3.2	3.6	4.0
3	2.6	....	4.0	4.8	3.1	3.3	4.5	5.1
10	2.5	4.2	5.5	7.0	4.0	4.3	6.8	6.6
17	2.3	5.0	7.2	8.0	4.7	7.3	7.5	7.8
21	2.6	5.8	7.1	7.9	5.8	....	7.8	8.0
28	....	....	7.9	8.2	5.9	....	....	8.2
56	6.0	7.7	8.3	8.6	6.7	8.0	8.0	10.0

[a] Not inoculated.
[b] Inoculated with *Achromobacter* sp. isolated from stored vacuum-packed German sausage.
[c] Inoculated with *Bacillus* sp. isolated from stored non-vacuum-packed German sausage.
[d] Inoculated with a mixed flora obtained from German sausage.

growth curves indicate a longer lag phase in vacuum-packed samples than in samples packed at atmospheric pressure.

Experimental series IV. In the experiments mentioned above a very low pressure, 3 mm Hg, was used for the vacuum-sealed packages. Since this pressure has very little practical significance, two experiments were carried out to elucidate the effect on bacterial growth of sealing pressures in the range between 3 mm Hg and atmospheric pressure. A storage temperature of 21°C was used, and the following sealing pressures: 3, 6, 12, 24, 96, 480, and 760 mm Hg.

As can be seen in Table 4, sealing at atmospheric pressure gives significantly higher bacterial counts than all lower sealing pressures.

Qualitative changes in microflora during storage. From platings carried out for determination of total bacterial counts, representative colonies were picked from the countable dilutions. Isolations were made from platings at the start of the experiment, after 2 days of storage, and at the end of the storage period from vacuum-packed as well as from non-vacuum-packed samples. Of the approx. 300 isolates obtained, the most predominant types were determined as to genus (Bergey's, 1957; Manual of Microbiological Methods, 1957).

Commercially produced processed meats usually possess a heterogeneous initial microflora, dependent on the product in question and on the basic microflora at the place of production. The samples examined in this work also showed a numerous and rather heterogeneous initial flora. Predominating organisms in sliced salt-cured meat were *Micrococcus* sp., in sliced German sausage *Lactobacillus* sp., and in wieners *Bacillus* sp. Samples of the laboratory-produced sausage with a low initial bacterial count showed an almost homogeneous microflora, consisting of *Bacillus* sp.

Fig. 4 shows the qualitative changes that took place during storage as judged by study of the microorganisms isolated throughout the experiment. Samples sealed at atmospheric pressure showed no qualitative changes in microflora during storage. The predominating microorganisms were in this case identical with the initial flora observed.

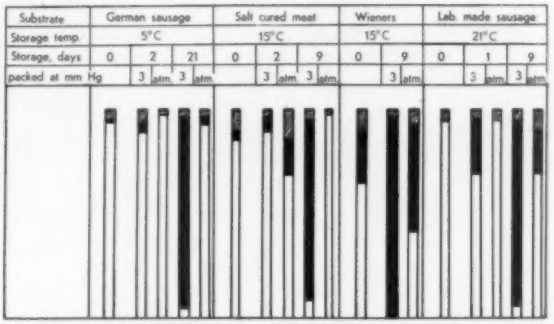

Fig. 4. Qualitative changes of the microflora in vacuum-sealed processed meat during cold storage. The dominant species are given as percentage of the total flora.

■ Bacteria species dominating in samples sealed at 3 mm Hg.
□ Bacteria species dominating in samples sealed at atmospheric pressure.
▨ An inhomogeneous flora not influenced by the sealing pressure.

Vacuum packaging, however, brought about a considerable qualitative change in the predominating microflora during storage. The originally predominating flora was more or less suppressed and replaced by other bacteria types. This phenomenon could be observed in the commercially produced samples as well as in the laboratory-produced samples.

The new predominating microflora varied somewhat with the type of the product. In sliced salt-cured meat, wieners, and sliced laboratory-produced sausage, the predominating organism was *Lactobacillus* sp., and in sliced German sausage *Achromobacter* sp.

Significance of initial bacterial numbers in the samples. It is known that the bacterial growth in stored samples is influenced by the initial number of bacteria. From the growth curves of 7 experiments with vacuum-packed and non-vacuum-packed samples, the correlation between initial bacterial numbers and growth was calculated. Fig. 5 shows the time for a sample with a certain initial bacterial number to reach a count of 5×10^5 organisms/g.

As can be seen, the difference between non-vacuum-packed and vacuum-packed samples in this regard is greater when the initial number of bacteria is low.

DISCUSSION

Our results showed that if flavor ratings are used as a criterion for keeping quality, vacuum-packed sliced processed meats maintain their acceptability over a longer period than samples packed at atmospheric pressure, this being true for all storage temperatures tested (Table 1, Fig. 1a, 1b).

For fresh meat, similar effects were reported by

Table 4. Log bacterial counts per g in samples packed at different pressures and stored at 21°C; two experiments (I, II).

Storage time (hr)	3 mm Hg		6 mm Hg		12 mm Hg		24 mm Hg		96 mm Hg		480 mm Hg		760 mm Hg	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II
0	1.8	1.7	1.8	1.7	1.8	1.7	1.8		1.8	1.7	1.8	1.7	1.8	1.7
17		3.3		3.2		3.9						3.7		5.1
18	1.8				2.1		1.9		2.1		2.1		3.3	
21		3.4		3.7						4.5				5.5
22	2.3		2.6	2.6	2.1		2.2		2.4		2.3		3.1	
41		5.5		5.6		6.4				6.8				9.3
42	3.5		2.8		3.6						4.6		6.0	
48	4.3		4.5		4.0		3.4		3.8		4.6		6.6	
66	5.8		4.4		5.2		3.9		3.8		5.2		7.5	
69		6.4		6.6		7.2				7.0				
72	6.0		5.6				4.7		5.8		5.7		7.8	
89		6.6		7.2		7.3								8.3
90	6.4		6.3		5.8		5.1		6.8		7.3		8.0	
96	6.7		6.4		5.6		5.6						8.4	
120	6.5				5.4		5.7				7.3		8.4	

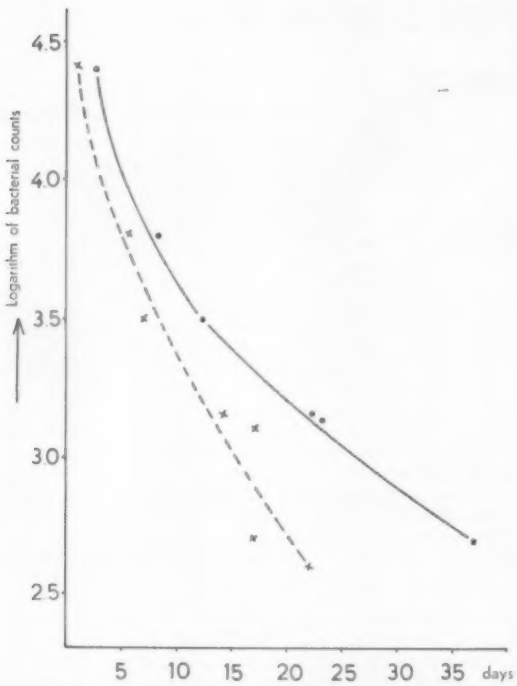

Fig. 5. Time required for a sample to reach a bacterial count of 5×10^5 organisms per gram at different levels of the initial bacterial flora. The storage temperature was 5° C and the initial bacterial counts were 500–25,000 organisms per gram.

● ——— ● sealed at 3 mm Hg.
× - - - - - × sealed at atmospheric pressure.

Brown and Schmucker (1960), who established an increase of flavor ratings in stored vacuum-packed bacon, and by Halleck *et al.* (1958b) for ground lamb.

Temperature is the most important parameter for growth of bacteria in prepacked processed meat, and vacuum packaging does not prevent growth at any of the storage temperatures examined. However, the bacteriological analysis consistently shows a lower bacterial level in samples from evacuated sealed bags than for bags sealed at atmospheric pressure (Table 2, Fig. 2, 3).

In our experiments we had a fairly low number of viable bacteria at the start: 100–25,000/g. The correlation between these initial numbers of bacteria and the time in days to reach a viable count of 5×10^5 organisms/g is shown in Fig. 5. If the time to reach a viable count of 5×10^5 organisms is taken as a measure of the sample's ability to keep fresh, it is seen from Fig. 5 that the prolongation of shelf life gained by vacuum packing is more pronounced for lower initial bacterial counts.

The dominating initial microflora of the processed meats used in these experiments was a mixture of *Bacillus* sp., *Micrococcus* sp. and *Lactobacillus* sp. This mixture stayed relatively constant in composition during storage in Cellophane polyethylene bags heat-sealed at atmospheric pressure. But in vacuum-packed samples there was a striking shift to almost a pure culture of *Lactobacillus* sp. in salt-cured meat and wieners, and to *Achromobacter* sp. in German sausage. This is partly in agreement with results reported by Allen and Foster (1960), who found a dominance of *Lactobacillus* sp. in vacuum-packed sliced processed meat.

The possible risks of growth of pathogenic anaerobes in vacuum-packed meat products was not studied. In our experiments, only a few anaerobes (<10/g) were represented in the initial bacterial flora, but growth of anaerobes was in no case established in vacuum-sealed bags. The failure of anaerobes to develop in the experiments might, however, indicate that factors other than oxygen pressure also determine growth of anaerobes in these types of meat products and under the conditions studied. The tendency of Lactobacilli to dominate in vacuum-packed meat might be a factor of importance to prevent growth of anaerobes, owing to the ability of *Lactobacillus* sp. to lower pH.

Acknowledgments

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Effect of Processing on the Absorption Spectra of Carotenoid Pigments of Badami Mango

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SUMMARY

Badami mango, used in the preparation of strained mango pulp and drum-dried custard powder, is a rich source of β-carotene. Canning of mango pulp results in considerable changes in the absorption characteristics of the carotenoid pigments. Subsequent storage of the canned product causes similar changes. Partial neutralization of the acidity in the mango pulp and the heating involved in the cooking and drum-drying of the mango custard blend do not, however, have any such effect. The reflectance data and the over-all visible color of the pulp as well as of the custard powder do not alter much during storage.

DURING INVESTIGATIONS toward the development of strained baby foods from indigenous fruits, Badami mango was used in the preparation of canned pulp and also drum-dried custard powder. It is a rich source of β-carotene, the carotenoid pigments consisting almost entirely of the β-isomer, together with two unidentified xanthophylls (Ram Sarma *et al.*, 1946). Heating involved in canning and drum-drying is likely to convert the protein-bound water-soluble pigment, first into a nonprotein-bound water-insoluble and later into a lipoid-soluble form (Joyce, 1954). Polgar and Zechmeister (1942) showed that heating isomerizes β-carotene into 9 or 10 pigments having various absorption maxima, and that it introduces into its absorption spectrum a *cis*-peak between 320 and 380 mμ, in the ultraviolet region (Zechmeister and Polgar, 1943). *Trans-cis* isomerization may either increase or decrease the adsorptive power on chromatographic column as compared to that of the respective all-*trans* carotenoid (Zechmeister and Tuzson, 1939; Polgar and Zechmeister, 1942). Isomerization has been reported in the case of leaf xanthophylls also (Strain, 1939; Zechmeister *et al.*, 1939). These changes may lead to deterioration not only in color but also in the flavor of the product (Joyce, 1954). It was, therefore, of interest to study the effect of various processes and subsequent storage conditions on the absorption spectra of the carotenoid pigments in the mango and also on the over-all color. The results are presented in this paper.

EXPERIMENTAL

Fresh ripe Badami mangoes were washed, peeled, and pulped in a stainless-steel pulper, and the pulp passed through a 60-mesh sieve. The pulp was then filled hot at 85°C into No. 2½ cans, and the cans sealed and processed for 30 minutes in boiling water and then cooled.

Mango custard blend was prepared according to the following recipe: 3200 g mango pulp (fresh or canned), 160 g skim milk powder, 160 g sugar, and 80 g starch (corn).

The starch was first cooked into a paste with a small quantity of water, and the paste mixed with sugar, milk powder, and mango pulp. The mixture was passed through a 40-mesh sieve and cooked 5 minutes in a stainless-steel steam-jacketed kettle. After adjusting acidity to 0.25% (pH about 5.6), the blended mix was homogenized. One portion of it was canned in 301 × 308 cans and processed 30 minutes at 10 psig. The second portion was dried in a Buflovak double-drum drier at atmospheric pressure, using steam at about 65 psig. The product, which dried in the form of a thin crinkled sheet, was ground into powder of 30-mesh size and the powder packed as such or gas-packed under nitrogen.

The canned pulp was stored at 1.7, 5, 24–28 (room temperature), and 37°C, and the custard powder at 5 and 37°C. The different lots were examined after 9 months of storage.

Analytical methods. Moisture was determined by drying the product for 8 hours in a vacuum oven at 70°C. The pH was taken with a Beckman pH meter with glass electrode.

Total carotenoid pigments were extracted with acetone and taken up in light petroleum (B.P. 60–80°C). β-carotene was separated on a magnesia-supercel column (1:3) according to the method of the Association of Vitamin Chemists (1951). Xanthophylls, which remain adsorbed on the column after elution of β-carotene, were eluted with acetone and immediately transferred to light petroleum. Total carotenoid color and β-carotene were measured at 452 mμ with a Beckman DU spectrophotometer, and the values expressed in terms of β-carotene.

Reflectance color of the product was measured with a Photovolt Reflectance Meter with Search Unit 610Y and three tristimulus filters—amber, green, and blue. Chromaticity coordinates were calculated according to the standard formula.

RESULTS AND DISCUSSION

Table 1 shows the absorption maxima of carotenoid pigments in mango pulp and custard powder.

The total pigments of fresh mango pulp gave absorption maxima at 443 mμ and 470 mμ (Fig. 1).

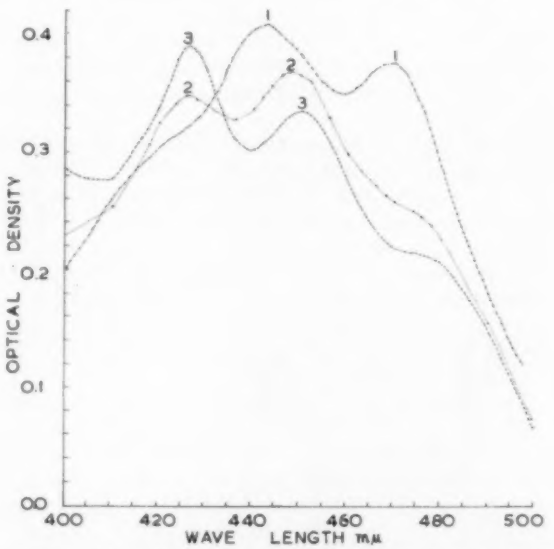
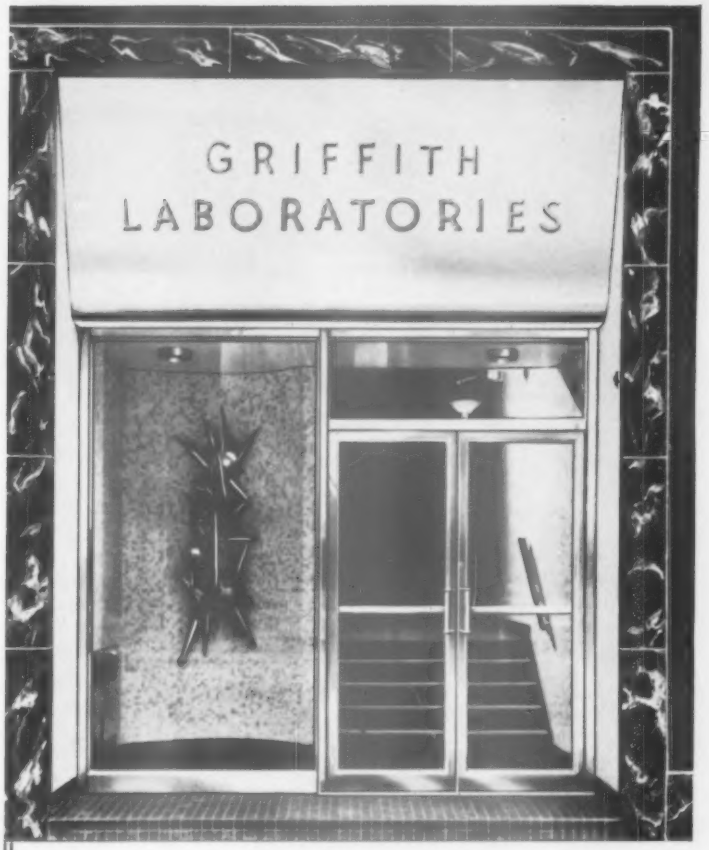


Fig 1. Absorption spectra of carotenoid pigments in fresh, canned, and stored Badami mango pulp: 1) fresh; 2) freshly canned; 3) canned and stored (10 month at 35° F).



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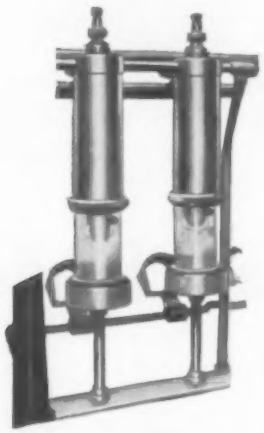

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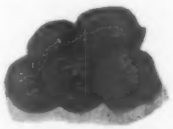

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Table 1. Absorption maxima (mμ) of total corotenoids, β-carotene and pigments other than β-carotene (xanthophylls) of some mango products.

	Total pigments		β-carotene		Pigments other than β-carotene (xanthophylls)		
	mμ	mμ	mμ	mμ	mμ	mμ	mμ
Fresh pulp							
Unsaponified	443	> 468–70	444	> 470	420	< 442	> 468–470
Saponified	448	470	450	> 476	420	440	470
Freshly canned pulp							
Unsaponified	426	< 448	450	No peak	424	> 448	No peak
Saponified	No peak	448	450	> 478	420–24	< 446–48	No peak
Canned pulp (stored 35°F for 10 months)	426	> 450	450–52	> 478	426	> 450	No peak
Mango custard powder prepared from fresh pulp	443	> 467	442	> 464	.....	438	> 466
					422	> 446	
Mango custard powder prepared from freshly canned pulp	426	< 448	450	> 474–478		436	> 466
					422	> 448	
Mango custard powder prepared from canned pulp stored	428	> 452	452	> 478–480	428	452	No peak

Although the β-carotene fraction in the samples chromatographed without prior saponification had absorption maxima at 444 and 470 mμ (Fig. 2) instead of the characteristic ones at 450 and 480 mμ (Ram Sarma *et al.*, 1946), on saponification with 12% methanolic potash by blending for 5 minutes (Assoc. of Vitamin Chemists, 1951), it gave the characteristic peaks. Xanthophylls gave absorption maxima at 420, 442, and 472 mμ, and constituted about one-third of the total carotenoid pigments in the extract.

Canning the pulp resulted in a shift to the left in the absorption maxima of the carotenoid pigments, from 443 and 470 mμ to 426 and 448 mμ, respectively, and there were also changes in the intensity of absorption at the different peak positions (Fig. 1). In the case of the fresh pulp, absorption was greater at 443 mμ than at 470 mμ. In the canned pulp, however, absorption was greater at 448 mμ than at 426 mμ. After storage at 1.7°C (35°F), the reverse was the case. Similar changes in the intensity of absorption were observed in the case of canned pulp stored 5, 24–28°C, and 37°C. There were, however, no significant shifts in the absorption maxima.

The β-carotene fraction from canned pulp gave the correct peak at 450 mμ even without any preliminary saponification prior to separation (Fig. 2).

On canning, there was a slight shift in the absorption maxima of the xanthophyll fraction from 420 and 442 mμ to 424 and 448 mμ, respectively. In the case of the stored pulp, there was a slight shift in the peaks from 424 and 448 mμ to 426–428 and 450–452 mμ, respectively.

Mango custard powder prepared from fresh mango pulp by drum-drying behaved almost in the same way

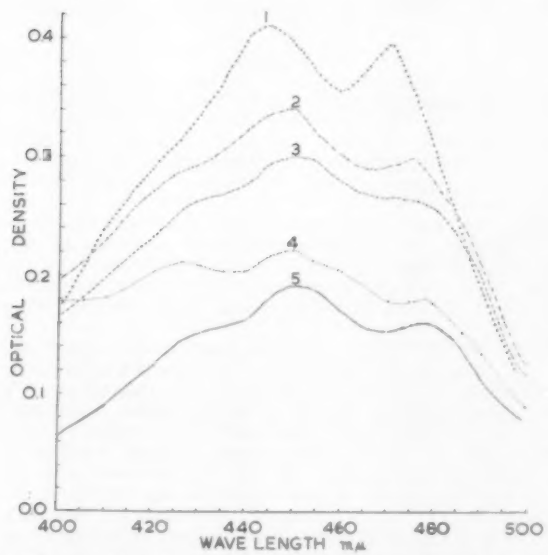

Fig. 2. Absorption spectra of β-carotene solutions: 1) fresh pulp, unsaponified; 2) fresh pulp, saponified; 3) freshly canned pulp, unsaponified; 4) freshly canned pulp, saponified; 5) canned pulp, stored (10 months at 35° F), unsaponified.

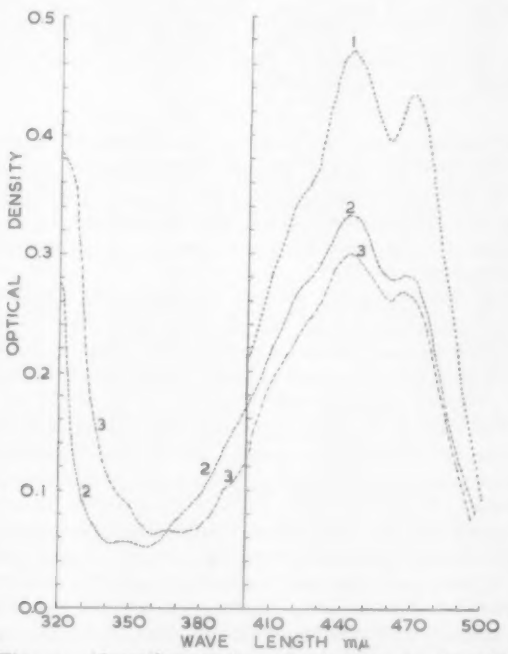

Fig. 3. Absorption spectra of pigments in drum-dried custard powder prepared from fresh Badami mango pulp: 1) total carotenoid pigments of fresh mango pulp; 2) total carotenoid pigments of drum-dried mango custard powder prepared from fresh pulp; 3) β-carotene from mango custard powder, unsaponified.

as fresh pulp with regard to absorption characteristics (Fig. 3). The results were practically the same in the case of custard made from canned mango pulp (Fig. 4), which represents the combined effect of heating due to canning and drying. Partial neutralization of the acidity of the mango pulp on heating involved in the process of cooking and drum-drying did not induce any further changes in the pigments. Further, canning and subsequent drum-drying did

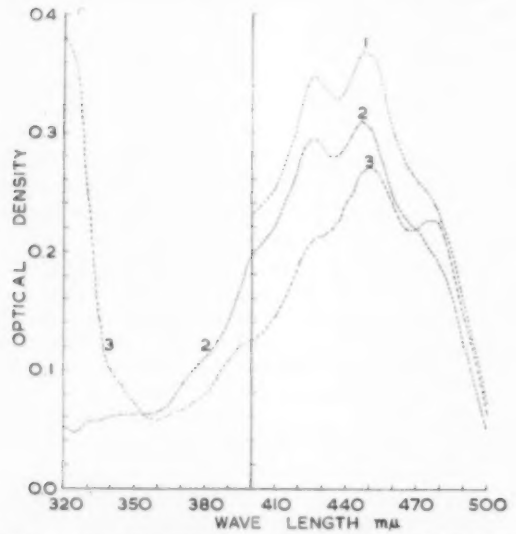

Fig 4. Absorption spectra of pigments in drum-dried custard powder prepared from freshly canned Badami mango pulp: 1) total carotenoid pigments of freshly canned mango pulp; 2) total carotenoid pigments of custard powder prepared from freshly canned mango pulp; 3) β-carotene from mango custard powder, unsaponified.

not introduce any *cis*-peak in the ultraviolet region at 320–380 mμ, either in the total pigment fraction or in the β-carotene isolate (Fig. 3, 4). These findings are thus different from those of Zechmeister and Polgar in the case of pure samples of isomerized carotenoids.

The comparatively greater changes in the absorption characteristics of the canned pulp may be attributed to the more prolonged heating than in drum-drying, where heating is only momentary, though at a higher temperature.

The data in Table 2 show that the carotenoid pigments are quite stable toward the various treatments during canning and drying. In the case of the custard powder, factors like gas packing in nitrogen or storing at 5 and 37°C do not alter the absorption curves.

In freshly prepared custard powder, using fresh or canned pulp, the xanthophylls are soluble in ether, but on storage of the product these become insoluble in ether. This phenomenon is irrespective of temperature of storage or type of packing, whether in air or in nitrogen. The xanthophylls, which are prob-

Table 2. Effect of partial neutralization of acidity and heating on β-carotene and total carotenoids in mango pulp and custard blend and powder prepared from canned pulp.

	Moisture (%)	pH	On dry weight basis: Total carotenoids (μg/100 g)	On dry weight basis: β-carotene (μg/100 g)
Mango pulp (strained)	81.75	3.7	36,500	24,960
Fresh custard blend	75.73	4.2	23,710[a]	16,220[a]
			23,750[b]	16,230[b]
Cooked custard blend (acidity partially neutralized)	77.45	5.0	23,790	15,920
Canned custard blend	76.95	5.0	23,460	16,020
Drum-dried custard powder	1.91	5.0	23,680	16,180

[a] Quantity expected.
[b] Quantity found.

ably present in the form of esters in the pulp, appear to break down during storage of the custard powder.

The following data for the chromaticity coordinates and luminous reflectance of canned mango pulp and drum-dried custard powder are typical:

	Canned mango pulp	Drum-dried custard powder
x	0.33	0.37
y	0.55	0.59
G%	43.0	41.5

Neither these nor the over-all visible color of the products was affected to any extent during storage for 9 months at 5°C or 37°C.

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Effect of Temperature on Stability of Commercially Frozen Bulk Pack Fruits—Strawberries, Raspberries, and Blackberries

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SUMMARY

Frozen strawberries and raspberries packed in 30-lb tins were about 2–3 times as stable as similar fruit in retail packages. In general, color and flavor stability was further increased in remanufactured products such as preserves and ice cream. The temperature quotient for color and flavor in strawberries, raspberries, and blackberries was definitely lower in preserves than in thawed fruit, indicating that the preserve form had less sensitivity to a rise in temperature. Data on the high-quality life of these berries in frozen and preserve form are given for temperatures in the range 0–30°F. Data on reduced ascorbic acid retention and the ratio of reduced to total ascorbic acid are presented and discussed.

THE STABILITY of strawberries and raspberries in retail packages has been studied (Guadagni *et al.*, 1957 a, b). But more than half the production of these frozen fruits is packed in bulk containers (30-lb tins, 1-gal. cans, barrels, etc.), primarily for subsequent remanufacture into preserves, ice cream, etc. Studies were therefore made of the effects of various subfreezing temperatures on the fruit itself and on initial products remanufactured from these fruits. This paper reports changes in the color, flavor, and ascorbic acid of fruits in 30-lb cans held at 0 to 30° F, and briefly discusses the differences between retail and bulk packs. Subsequent reports will deal with the effect of storage and processing procedures on shelf life of the remanufactured products.

MATERIALS AND METHODS

All of the berries were standard commercial packs obtained from freezing plants in California and Oregon during the 1954 and 1955 seasons. There were 6 lots of berries, each consisting of 35 cans of fruit. Shasta and Marshall varieties of strawberries were washed, sorted, and packed whole in 30-lb tins with dry sugar in a 4+1 ratio. Washington variety raspberries and Evergreen blackberries were washed, sorted, and packed in 30-lb tins without sugar. All cans were frozen in commercial air-blast freezers operated at −15 to −25°F.

All samples were transported to Albany, California, under dry-ice refrigeration and held at −20°F until placed at experimental temperatures of 0, 10, 20, and 30°F. At appropriate intervals, 1 or 2 cans were removed and rapidly cooled to the control temperature of −20°F. Controls for all experimental temperatures and all lots were maintained continuously at −20°F.

For comparison of representative samples held at the higher temperatures with controls held at −20°F, 30-lb cans of both experimental and control samples were thawed for 24 hours at 70°F. Center temperatures then ranged from 24 to 28°F. After thawing, representative samples were taken for organoleptic evaluation, pigment determinations, reflectance measurements, and ascorbic acid determinations. The remainder were used for manufacture into ice cream and preserves. This procedure was used in evaluating each of the different time-temperature conditions studied. Hereinafter, "thawed fruit" or "fruit" refers to fruit immediately after thawing.

Organoleptic Evaluation. Color and flavor changes were determined on the thawed fruit, in ice cream, and in preserves. The triangle test (Guadagni, 1957) was used with 10–15 trained judges, who evaluated the various samples 2 or 3 times, giving a total of 20–30 judgments. Samples from experimental temperatures were always judged against −20°F controls.

For ice cream comparisons, 20% of fruit was added to a basic mix consisting of 12% fat, 10% nonfat milk solids, 16% sugar, and 0.25% gelatin stabilizer. The mix was aged overnight, frozen in a batch-type mechanical freezer to an overrun of 85%, and drawn at 24°F. The packaged ice cream was hardened at −20°F and held there until evaluated. To facilitate tasting, samples of ice cream were allowed to reach 10°F overnight just before flavor evaluations, which were always made within two weeks of preparation.

Preserves from these fruits were prepared in a steam-jacketed 5-gal. vacuum kettle operated at 10 lb of steam pressure. The product was cooked at a vapor temperature of 135°F to 68% soluble solids, then rapidly heated with stirring to 190°F, filled hot into glass jars, steam-flow sealed, and rapidly cooled. The entire cooking, pasteurizing, filling, and sealing operation took about 15 minutes per batch. All preserves consisted of 45% fruit, 55% sugar, and just enough pectin and acid to give the desired consistency.

Objective Measurements. Reduced and total ascorbic acid in the thawed fruit was determined by procedures previously described (Guadagni and Kelly, 1958). Pigment content in strawberries was estimated by the method of Sondheimer and Kertesz (1948) as modified by Meschter (1953) and in raspberries and blackberries by measuring the absorbance at 515 mμ of a water extract of the berries adjusted to pH 3.0. Color reflectance of the thawed fruit was determined on a Gardner automatic color difference meter standardized with a red tile having the following values: $L = 24.4$, $a = 15.7$, $b = 4.3$.

RESULTS AND DISCUSSION

Color and Flavor. It is convenient to discuss the organoleptic results in terms of the concept of "high-quality life" discussed in an earlier report (Van Arsdel and Guadagni, 1959) and defined here as the holding period at the specified temperature required to produce a change in flavor or color detected by 60–70% of the judges. Table 1 shows the range of high-quality life found in this study for both thawed fruit and remanufactured products. Values for ice cream and preserves were obtained by comparison of

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Table 1. Effect of temperature on high-quality life of strawberries, raspberries, and blackberries as determined by trained taste panels.

		Range of high-quality life (weeks)				
		Thawed fruit		Preserves		Ice cream
	°F	Color	Flavor	Color	Flavor	Flavor
Strawberries	0	78–104	78–104	100–120	100–120	100–110
	10	12–16	12–16	28–36	52–60	30–40
	20	2–3	2–3	7–9	25–30	8–12
	30	0.5–1	0.5–1	1–3	.....	2–3
Raspberries	0	70–86	104	24–28	104	104
	10	25–30	43–47	11–15	75–85	75–85
	20	5–9	8–12	5–9	25–30	25–30
	30	1–3	2–3	2–4	6–10	6–10
Blackberries	0	104	78–104	80–88	74–82	
	10	60–70	34–45	28–36	30–36	
	20	25–30	5–9	13–17	10–16	
	30	9–11	2–4	5–10	5–7	

the stored and control fruit prepared in these forms.

Fruit color and flavor measurements for strawberries indicate that high-quality life in bulk packs is almost double that of retail packs, and for raspberries it is about 3 times as long as in retail packs. Greater stability in the bulk containers is probably associated with the fact that the 30-lb tin, even though not hermetically sealed, is much more protective against oxygen diffusion than the ordinary composite containers used for retail packs. Another important difference is that the retail pack has a much greater surface-to-volume ratio than does the bulk pack. This, of course, tends to enhance oxidation in a greater proportion of the fruit in retail than in bulk containers. While no comparative color and flavor data are available for both types of pack in blackberries, it is likely that the general relationship is the same.

With regard to flavor of the thawed fruit, it appears that all three fruits have a high-quality life of about 2 years at 0°F. At 10–30°F, however, raspberries and blackberries have a much longer high-quality life than do strawberries. This same general relationship is true for color stability, except that blackberries are much more stable than raspberries, and raspberries are at least twice as stable as strawberries in the 10–30°F range. The flavor stability of strawberries and raspberries is markedly increased when the fruits are made into ice cream and preserves. Obviously the masking effect of fat in ice cream and sugar in preserves definitely plays a part in this apparent increase in flavor stability.

In blackberries, however, increased flavor stability was evident only at 20 and 30°F. Furthermore, color stability in blackberries was greater in thawed fruit than in preserves. At temperatures of 0–10°F, color stability in raspberries was greater in thawed fruit than in preserves, but at 20–30°F this difference was not evident. Color stability was much greater in strawberry preserves than in thawed fruit over the range of 0–30°F. Differences between the three fruits in color stability in thawed fruit and preserves are not readily explainable. A possible clue may be the fact that blackberries and raspberries have a much higher pigment concentration than strawberries and that the former fruits in preserve form are essentially a puree whereas the latter is mostly whole fruit.

Temperature Quotients. If the average of the range of times listed in Table 1 is plotted against temperature on semilogarithmic paper, the data are reasonably well represented by straight lines for color and flavor in both thawed and preserved fruit. Similarly, data from average rates of pigment loss and reflectance changes plotted against temperature are also reasonably well represented by straight lines, indicating an exponential relation between rate of color and flavor deterioration and temperature in the 0–30°F range. Under these conditions, it is possible to express these quality attributes by simple temperature quotients as discussed by Plank (1959) and by Kuprianoff (1956).

For our purposes, it is convenient to express the temperature quotient as the ratio of the high-quality life at a particular temperature to the high-quality life at a temperature higher by 10°F. Letting L_t represent high-quality life at temperature t°F, the temperature quotient is defined by $q = \frac{L_t}{L_{(t+10)}}$. For objectively measured physical and chemical changes, the temperature quotient q is defined as $q = \frac{R_{(t+10)}}{R_t}$, in which R_t represents the rate of change of the measured property at t°F. Table 2 gives values of q, L_0 and R_0 observed for strawberries, raspberries, and blackberries. Plank (1959) thoroughly discussed the relationships among temperature quotient, reaction speed, and temperature coefficient, and gave formulas for calculating each of these parameters under specified conditions. From these relationships and the data in Table 2, it is possible to calculate the average rate of change in relative redness (Gardner "*a*" value), average rate of pigment loss, or the average high-quality life based on color or flavor at any desired temperature in the range 0–30°F.

Table 2. Average rates of change of flavor and color at 0°F in thawed fruits and preserves and their temperature quotients.

	High-quality life							
	Visual color		Flavor		Relative redness		Pigment loss	
	q	L_0 (wk)	q	L_0 (wk)	q	R_0[a]	q	R_0[b]
Strawberries								
Thawed	6.0	91	6.0	91	3.1	65×10^{-4}	5.6	24×10^{-4}
Preserves	3.7	110	2.0	110	....	....	....	....
Raspberries								
Thawed	3.2	80	3.8	140[c]	4.5	25×10^{-4}	2.5	25×10^{-4}
Preserves	2.1	28	3.1	250[c]	....	....	....	....
Blackberries								
Thawed	2.8	170[c]	3.1	91	....	....	4.9	66×10^{-4}
Preserves	2.4	78	2.3	84	....	....	....	....

[a] In units of change in "a" value per day.
[b] In units of percentage loss per day.
[c] Extrapolated values.

The temperature quotient for color and flavor in the fruit are not markedly different, indicating a similar effect of temperature on both quality attributes. Of the three fruits studied, strawberries had the highest q values, raspberries the next highest, and blackberries the lowest. Except for strawberries, the q values

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for pigment loss or rate of change in relative redness were not particularly close to those obtained for visual color changes in the fruit.

For preserves, however, the q values for color and flavor were always considerably lower than those for corresponding thawed fruit. With respect to color and flavor changes, this indicates that conversion of the fruit into preserves, in effect, decreased its sensitivity to a rise in temperature. Difference in q values between fruit and preserves was greatest in strawberries and least in blackberries.

Ascorbic Acid. Fig. 1 shows a typical example of ascorbic acid changes in 30-lb containers of 4+1 strawberries. It is readily apparent that this vitamin oxidizes faster and to a much greater extent in the top layer of berries than in the subsurface contents. Entrapped headspace oxygen plus diffusion through the friction seal of the lid undoubtedly account for this differential between top and bottom layers. Since the top layer represents only a minor proportion of the whole can, the total percentage loss of ascorbic acid is fairly small. It is interesting to note that curves for the bottom fruit show a tendency to level off at an ascorbic acid value of about 32–34 mg/100 g, indicating oxygen tension as a limiting factor. As shown in Table 3, ascorbic acid retention in strawberries and raspberries at 0–30°F was about 70–80% of the original amount. In blackberries, the figures are approximately 60–70%. Since original ascorbic acid in raspberries and blackberries is relatively low, particularly in the latter, this high retention is not very significant from a nutritional standpoint. In strawberries, however, the retention shown provides a significant amount (30–45 mg/100 g) of ascorbic acid throughout the high-quality life of the product at 0–30°F. Since reduced ascorbic acid values tend to become essentially constant at or near the end of high-quality life at these temperatures, percentage of total ascorbic acid in reduced form is also essentially constant (Table 3). Reduced ascorbic acid values of about 60–65% in strawberries and 40–45% in raspberries roughly correspond to the range of high-quality life as listed in Table 1, and hence the ratio of reduced to total ascorbic acid may be useful as a guide in estimating quality loss.

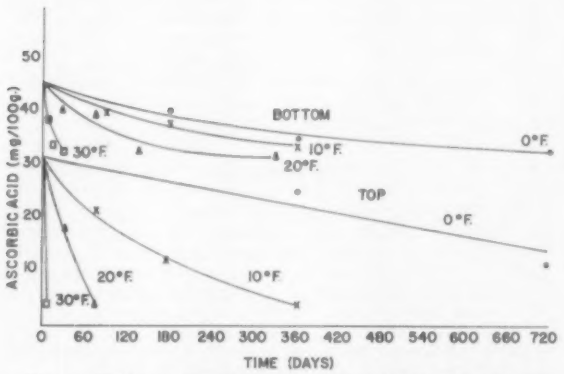

Fig. 1. Effect of temperature on reduced ascorbic acid content of 4 + 1 strawberries. "Top" refers to top layer of berries in a 30-lb can, and "bottom" refers to subsurface contents.

Table 3. Reduced ascorbic acid retention and ratio of reduced to total ascorbic acid during high-quality life of strawberries, raspberries, and blackberries.

	Strawberries		Raspberries		Blackberries
°F	Original reduced AA retained (%)	% of total as reduced AA	Original reduced AA retained (%)	% of total as reduced AA	Original reduced AA retained (%)
Control (−20°F)	100 (46 mg/100 g)	78	100 (16 mg/100 g)	60	100 (7 mg/100 g)
0	72	63	75	46	72
10	76	62	80	45	60
20	73	65	75	44	72
30	76	60	70	43	60

In general, stability of these fruits in 30-lb tins is such that normal commercial frozen storage and handling should rarely, if ever, be the cause of poor quality in preserves or ice cream manufactured from these fruits.

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Objective Tests for Quality of Ground Beef

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SUMMARY

In ground beef stored 10 days at 7°C (43°F) the bacterial count, pH, and ammonia content progressively increased, and the methylene-blue reduction time decreased. Spoilage was distinctly evident to the senses after 5 days, at which time bacterial count was 188 million per gram, and methylene-blue reduction time was 30 minutes. Of 59 samples of ground beef from retail markets, 42.4% reduced methylene blue within 2 hours, 23.7% required 1 hour or less, and 10.2% required only 30 minutes. Correlation was good between reduction time, bacterial count, and pH.

THE FRESHNESS of ground or comminuted meats is soon lost during storage at the temperatures common in retail markets. Before the deteriorative changes are detectable to the senses, objective laboratory tests may reveal progressive variance from the fresh product.

Numerous tests have been proposed for detecting incipient or threshold spoilage of ground meats. Since spoilage is a consequence of microbial activity, bacterial count has long been suggested as a criterion of quality (Elford, 1936; LeFevre, 1917; Tobey, 1948; Weinzirl and Newton, 1914b; Weinzirl, 1924). Others have suggested tests for certain groups of bacteria, such as anaerobes (Hoffstadt, 1924; Weinzirl, 1924) and *Proteus* (Sirotinina, 1937; Weaver, 1928). Tests have been made for bacterial products, such as ammonia by Falk, Baumann and McGuire (1919a, b) and Postema (1942), and for hydrogen sulfide by Richardson and Scheruble (1908) and Weaver (1928).

Other proposed criteria for spoilage include pH, carbon dioxide, biochemical oxygen demand, purine nitrogen, surface tension, volatile acids, conductivity, and methylene-blue or resazurin reduction time (Jensen, 1945; Perez, 1943; Proctor and Greenlie, 1939). Rogers *et al.* (1958) suggested the oxidation-reduction potential as a rapid test.

To be useful in the control of ground meats in the market place, a test of freshness must give results in minutes or a few hours, and require neither highly trained technicians nor elaborate equipment. The pH and methylene-blue reduction time appear to offer some promise. These determinations are compared herein with plate counts and ammonia determinations.

METHODS

Samples of ground meat were procured from retail markets as described by Rogers and McCleskey (1957). For the various tests, 10-g portions were blended for 2 minutes with 90 ml sterile water. Ammonia determinations were made with the Hawk *et al.* (1947) modification of the aeration method of Van Slyke and Cullen. The methylene-blue reduction time was determined in accordance with procedure as described in "Standard Methods for the Examination of Dairy Products" (Am. Public Health Assoc., 1948). Dilutions from the blender (1:20, 1:40, and 1:80) for the reduction test were made in sterile skim milk by transferring 10 ml of the 1:10 blender slurry consecutively into 10 ml of sterile milk. The respective concentrations of the milk were therefore 50%, 75%, and 87%. In most cases, readings were made at 30 minutes, 1 hour, and then at hourly intervals for 7 hours. Bacterial counts were made in the customary manner with Difco tryptone glucose extract agar. A Beckman model G potentiometer was used for measuring pH.

RESULTS

Table 1 shows the relationship between bacterial count, pH, ammonia content, and methylene-blue reduction time of a sample of fresh ground beef stored at 7°C (43°F). During the first 3 days there was little change in pH, ammonia, or reduction time, and the bacterial population remained relatively low. The next 2 days showed extensive changes in all these criteria. The first distinct odor of spoilage, noted after 5 days, was intensified as the changes progressed with continued storage.

Table 1. Bacterial count, pH, ammonia content, and methylene-blue reduction time of ground meat stored at 70° C.

Days stored	Sample	Count/gram	pH	Ammonia (mg/gram)[b]	Reduction time (hr) at 4 dilutions 1:10	1:20	1:40	1:80
0	A	43,000	5.9	.15	7	8	9	9
	B	48,000	5.9		6	7	8	8
3	A	2,225,000	6.0	.21	3	7	8	9
	B	2,120,000	6.0		3	7	8	9
5[a]	A	180,000,000	7.0	.40	0.5	0.5	1	3
	B	182,000,000	7.0		0.5	0.5	1	3
7	A	1,000,000,000	7.85	.88	0.5	0.5	1	2
	B	970,000,000	7.35		0.5	0.5	1	2
10	A	1,800,000,000	7.70	1.05	0.5	0.5	1	1
	B	1,900,000,000	7.70		0.5	0.5	1	1
12	A	1,945,000,000			0.5	0.5	0.5	1
	B	1,800,000,000			0.5	0.5	0.5	1

[a] Odor of spoilage noted first on 5th day.
[b] Average of 2 samples.

Three criteria of freshness—pH, bacterial counts, and methylene-blue reduction time—were applied to 59 samples of ground beef collected from retail markets by a sanitarian. The results (Table 2) indicate good correlation between the

Table 2. Quality tests applied to ground beef samples from retail markets.

Reduction time[a]	No. samples	Av count[b]	Av pH	% of total samples	Cumulative %
15 min	1	3,500	7.6	1.7	1.7
30 min	5	717	6.7	8.5	10.2
1 hour	8	287	6.4	13.5	23.7
2 hours	11	216	6.3	18.7	42.4
3 hours	8	68	6.2	13.5	56.0
4 hours	11	25	6.2	18.7	74.7
5 hours	8	10.8	6.1	13.5	88.2
6 hours	6	4.8	6.0	10.0	98.2
7 hours	1	9	6.0	1.7	100.0

[a] In 1:10 dilution.
[b] Millions per gram.

three tests when average counts and average pH values were compared with methylene-blue reduction time. On individual samples, however, agreement was less. The variations in counts and pH values for each reduction-time interval are shown in Table 3. The wide variations in plate counts on

Table 3. Relationship of methylene-blue reduction time to bacterial counts and pH.

Reduction time	No. samples	Millions per gram			pH		
		High	Low	Av	High	Low	Av
15 min	1			3,500			7.6
30 min	5	1,390	320	717	6.8	6.3	6.7
1 hour	8	470	50	287	7.2	6.0	6.4
2 hours	11	560	89	216	6.5	5.9	6.2
3 hours	8	109[a]	51	68	6.6	5.8	6.2
4 hours	11	113[b]	4	25	7.1	5.9	6.2
5 hours	8	27	5	10.8	6.6	5.6	6.1
6 hours	6	8	0.9	4.8	6.3	5.8	6.0
7 hours	1			9.0			6.0

[a] One sample over 100 million.
[b] Two samples with counts over 50 million.

samples with the same reduction time may be attributed to differences in the microbial flora, either in kinds or in biological activity of the cells. It is well known that reducing activity is much greater for some species than for others. Some of the discrepancies between the count and anticipated reduction time may be due to the mixing of certain chemicals in the meat as preservatives or for improved color. Although additives are prohibited by regulatory agencies, it is known that they are sometimes employed. The highest count (560 million) in the 2-hour reduction-time group was obtained on a sample with pH 5.9. A pH value of 5.9 could scarcely be expected except in fresh meat taken directly from the grinder, and certainly not in meat with such a high bacterial population. It is suspected that this sample, and others with very high count, low pH, and abnormally long reduction time, may have been altered by a chemical treatment that lowered pH and reduced the bacteria to semidormancy. None of the samples with a reduction time of 3 hours or less had counts below 50 million per gram, and none of the samples with a methylene-blue reduction time of 2 hours or less contained fewer than 89 million per gram.

The relationship of bacterial numbers to methylene-blue reduction time in two dilutions of ground meat is indicated in Table 4. The scale of difference between good and bad

Table 4. The effect of dilution on methylene-blue reduction time.

Millions per gram	No. samples	Reduction time (hours)					
		1:10 dilution			1:20 dilution		
		High	Low	Av	High	Low	Av
Under 10	16	7	4	5.2	8	5	6.2
10 to 49	6	5	4	4.5	7	5	5.6
50 to 99	13	4[a]	1	2.5	6	2	3.7
100 to 499	17	4[a]	0.5	1.6	6	0.5	2.6
500 to 999	3	2	0.5	1.0	3	1.0	1.6
Over 1000	2	0.5	0.5	0.37	0.5	0.25	0.37

[a] One sample only.

samples is shown better with the 1:20 dilution of the meat, but the 1:10 dilution has the important advantage of more rapid results.

DISCUSSION

Since ground meats rarely if ever make the consumer ill, it may appear that improved methods for control of the product are not needed. For aesthetic reasons, however, if not for health considerations, it would be desirable to restrict the sale and consumption of a product approaching a state of frank putrefaction. With present knowledge of sanitation and common use of refrigeration, great improvement in the quality of ground meats is possible without causing hardship to the dealer.

Ground meat, like milk, is a highly favorable medium for microorganisms, and must be produced and stored with due recognition of its perishable nature. The sanitarians who inspect markets need the support of one or more objective tests that can be completed within a few hours at most. Objective and quantitative tests of the quality of ground beef, carried out at irregular and unannounced times, as is now done to detect preservatives, would do much to improve the quality of the product offered the consumer. The need for improvement is shown by Rogers and McCleskey (1957) and the data of Table 3.

The methylene-blue reduction test appears to be a satisfactory method of evaluating the quality (freshness) of ground beef. The test is relatively rapid, requires little training, and little equipment. Most city and county laboratory workers are familiar with this test as carried out with milk; it can be done as easily on the supernatant of blended (1:10 dilution) samples of ground meat. It should not be expected that the methylene-blue reduction test will always agree with bacterial count, pH, ammonia content, or any other test for microbial products. The reduction time is dependent on the intensity of the reducing activity of the microbes. A small number of cells that are highly active physiologically may induce more rapid reduction than a much larger number of less active cells. In the control of ground meats the bacterial count may be superior in some respects to a reduction test, but the reduction test has the important advantages of speed, simplicity, and cheapness. In general, the reduction test shows good correlation with other criteria of freshness such as pH, ammonia content, and bacterial count.

In control work it is necessary to decide on the limits of tolerances. In this area, a reasonable starting point for a trial period appears to be a methylene-blue reduction time of more than 2 hours. Had this rule been applied to our series, no sample containing fewer than 89 million bacteria per gram would have been condemned, yet 42.4% of the samples would have failed to meet the test. This requirement could be changed to a reduction time of at least 4 hours if experience justifies.

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Control of Rutin Discoloration in Canned Asparagus*

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SUMMARY

A study was made of the factors affecting rutin discoloration of canned asparagus as well as means for their control. Effective control of this type of discoloration was accomplished by: a) harvesting only less mature spears, b) avoiding iron contamination from processing water or equipment, and c) use of added citric acid.

DISCOLORATION OF CANNED ALL-green asparagus has been a sporadic but increasingly frequent problem. This discoloration, as associated with rutin, may be defined as discoloration occurring after the container is opened and the product exposed to the air: the normal bright green changes to various intensities of dark black-green. In addition, the brine often exhibits blackish-green streaks at the surface. The degree of discoloration may range from barely perceptible darkening after standing an hour, to a dark black-green developing within 10–15 minutes of opening. Rutin discoloration has also been called asparagus "darkening" or "blackening."

Increasingly frequent asparagus discoloration may be due to various factors: greater production of all-green asparagus; increased use of a greater percentage of younger, tender spears and cuts; and greater awareness by both wholesaler and consumer.

The discoloration reaction is believed similar in nature to the ferric-tannate reaction that causes discoloration in certain foods. Although tannins have not been identified in asparagus, Stevenson (1950) reported investigation of color changes in canned asparagus wherein the flavonol glucoside present was identified as rutin.

The basic chemical reactions of rutin-discoloration in asparagus have not been specifically characterized, but the authors theorized that discoloration is initiated by oxidation of the ferrous (Fe^{++}) ion; the ferric ion in turn combines with rutin or a rutin complex, causing discoloration. There is also some possibility that tin reacts with rutin or a rutin complex, thereby causing it to be unavailable for the ferric-rutinate discoloration reaction. Thus the more specific term "rutin discoloration" is suggested as

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defining this particular discoloration phenomenon more clearly.

Stevenson (1950) found rutin content to be 3–4 times as great in asparagus tips as in the remainder of the edible stalk; also, that rutin content increases as the asparagus plant passes from the edible to the more mature stage, particularly after cladophyll development.

With a view toward solving the asparagus discoloration problem, Dame *et al.* (1957a, b, 1959) investigated the chemical composition of all-green asparagus. They showed that, on a weight basis, rutin increases with height of the spear above ground, and with decreased spear diameter. Their findings showed rutin was of highest concentration in the tip and of lowest concentration in the spear base (Figs. 1, 2). They also showed that rutin concentration changed little or not at all when fresh-cut asparagus was stored at 65°F under low humidity or stored in the sun in the fields, and increased only slightly when stored under moist conditions at room temperature. Changes were associated with increases in spear length.

Dame *et al.* (1957b) reported a 22% reduction in rutin concentration of asparagus water-blanched 3 minutes at 212°F, and only small changes in rutin concentration during steam blanching. They also reported citric and malic acids to be the main acid constituents of green asparagus, and that citric acid concentration in the 4-in. tip increased with increasing spear height. Contrary to expectation, hydrogen-ion concentration was lowest in the tip section because of the highly buffered system in asparagus.

Observations over many years (Continental Can Co.) have shown that discoloration-prone canned asparagus had a pH of 5.85–6.2, whereas canned products not showing discoloration usually had a pH of 5.7 or below. Also, iron content was relatively high in the discolored asparagus product, whereas in undiscolored controls the tin content was considerably greater than iron content.

Discoloration has been observed mainly in the larger (institutional-size) containers, such as the standard #10 (603 × 700). There have been few reports of discoloration in smaller (consumer-size) containers.

Thus, various basic factors appear to control development of the ferric rutinate complex in canned all-green asparagus: 1) rutin content of the asparagus; 2) iron content of the canned product; 3) tin content of the canned product; and 4) pH of the canned product. Since the rutin content of asparagus has been thoroughly investigated, the work presented here was designed to show the effects of iron and tin content and pH of the product on asparagus discoloration and to determine practical canning procedures for avoiding discoloration in canned all-green asparagus.

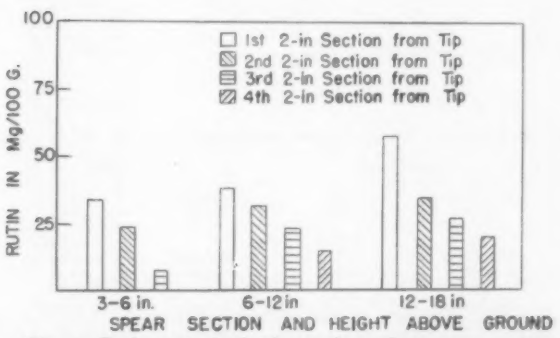

Fig. 1. Rutin content of 2-in. sections of asparagus spears processed after harvest at different heights aboveground (after Dame et al., 1957 a).

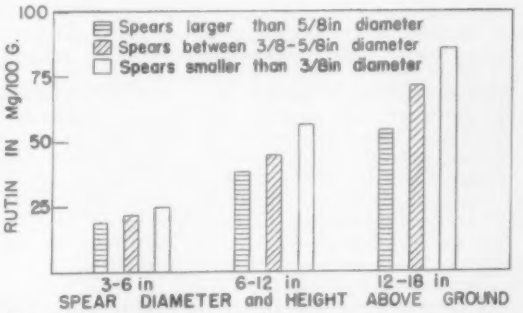

Fig. 2. Rutin content of 4-in. tips of asparagus processed after harvest at different heights aboveground (after Dame et al., 1957 a).

EXPERIMENTAL

Raw-product treatment and canning procedure. The raw product was obtained from commercial deliveries of asparagus to canning or freezing plants in the Michigan and Illinois area. For the 303 × 406 test packs, spears ⅝ in. or less in diameter were selected because of expected higher rutin content. The raw product was brought to our Metal Division Research and Development Center in Chicago and held in 40°F storage until processed. Soaking and spraying were carried out by holding the product 12 hr in stainless-steel sinks, followed by either immersing the product in running water or using a continuous water spray. Before soaking asparagus in water containing added ferric ammonium alum, soak water was made up to appropriate iron content of 25, 50, or 100 ppm.

For the 303 × 406 cans, canning was accomplished by trimming about 5-in. tips from all spears, cutting them into 2- to 2½-in. cuts, washing, and blanching 2 min in water at 210°F. Each can was filled with 10 oz of cut blanched asparagus and check-weighed, and 6 oz of the appropriate 2½% salt brine was added at 190°F–210°F. For the 303 × 406 cans, sufficient citric acid was added to the salt brine to obtain the denoted concentration in total can contents at equilibrium (based on a 6-oz brine fill and 16-oz net contents). Filled cans were then closed under 5 psig on the steaming device, retorted 24 minutes at 240°F, and water-cooled.

The #10 cans were packed at a commercial cannery. Asparagus cuts 5/16 in. or less in diameter (removed from larger cuts with a shaker screen) were water-pumped to overhead storage tanks, gravity-fed to the filling table, and packed into cans (66 oz per can), filled with hot water at 180–190°F, and appropriate salt tablets added. The cans were then closed, retorted 30 minutes at 240°F, cooled, and cased.

Treatment of containers. The commercial 303 × 406 cans used had 1.25# plain hot-dipped tinplate bodies and #25 electrotin "C" enameled ends. These cans were treated electrochemically to deposit an extremely heavy oxide film on the plain bodies. Empty cans were completely filled with a 5% sodium carbonate solution, and a carbon electrode was inserted into the solution at the can center. The original oxide film was then removed electrochemically by suitable current direction, using a battery charger. The current was next reversed for 10 seconds to deposit a uniform, heavy oxide film on the plain bodies.

The commercial #10 cans used had plain (unenameled inside) 1.25# hot dipped tinplate bodies and ends. (These cans were not treated electrochemically to remove and redeposit a heavy oxide film.)

Container storage. Packed cans for shelf life and product evaluation were held in controlled-temperature storage at 70°F and 100°F until opened, or examined for vacuum loss as determined by the end flip test described by Skibbe (1955).

Chemical analysis. Rutin content was determined after the procedure of Dame *et al.* (1957a) with some modifications in the amount of buffer and aliquot sizes.

Iron content of asparagus brine and asparagus was determined by the wet ash procedure using ortho-phenanthroline as the iron-complexing reagent.

Tin content was determined by wet-ashing brine samples and determining tin polaragraphically.

Electrochemical tests of tinplate surfaces. Polarization tests of tinplate surfaces were conducted by imposing known currents against the plate surface and measuring the plate's change in potential. The electrochemical tests were made by exposing an area of 2.1 sq in. to the media. A 4.0 sq-in. disc was cemented to one end of a polyethylene tube (1¾" ID × 2" OD) and tested as the bottom end, while the other end (top) contained the platinum and calomel reference electrode and flushing tubes mounted in a rubber stopper. Asparagus brine (1.0 cc formalin added to prevent microorganism spoilage) was placed in the test cell and the rubber stopper attached. The brine was flushed 2 hr with nitrogen gas, and the test cell was sealed. The test cell stood (open circuit) for 24 hours at room temperature (74°F) before the anodic polarization characteristics of the sample plate were determined. Potentials were determined against a saturated calomel reference electrode, using a Leeds and Northrup potentiometer.

RESULTS AND DISCUSSION

Effect of soaking asparagus on pH. In certain areas, cherry tanks are used for holding raw asparagus until it is canned. To avoid overheating, water is usually circulated continuously during the holding period. Water immersion of asparagus during holding was believed to leach out sufficient organic acids to cause an increase in pH. Therefore, experiments were conducted to determine the effect of soaking versus spraying on the pH of fresh asparagus. The results are in Table 1.

These data show a trend toward an increase in pH of asparagus during water immersion or soaking, contrasted to little or no pH change when water is sprayed. A similar relationship carried through to the canned product. Higher pH values after blanching were also obtained, indicating further leaching of organic acids during blanching.

Effect of incidental iron addition. Most cherry tanks are constructed of steel plate. This could result in relatively high iron content of soak water and could contribute to iron pickup by the raw product during immersion holding. A study was therefore made of how rutin discoloration is affected by the addition of iron to soak water. The results are in Table 2.

The immersion studies with added iron were carried out in stainless-steel sinks for 12 hours. Although precipitation of ferric salts was noticeable in all soak water to which ferric ammonium alum was added, the main purpose of addition was to have ferric iron available in increasing quantities. These conditions are similar to the commercial situation in which relatively insoluble ferric oxide is most likely to be present. These data show definite increases in iron content of the fresh product after soaking in water of increasing iron content, and a limited corresponding trend toward higher iron contents of cut-out brine. The variations in iron content after 3 and 6 months of storage of the canned product are attributed to variation in the dissolution of iron from the container. The data nevertheless illustrate that relatively little iron pick-up may contribute materially to asparagus discoloration. Other factors such as tin content, pH, rutin content, iron take-up, and availability of iron, as well as sample variation, also affect the degree of discoloration. Thus, a straight-line relationship between iron content of soak water and degree of discoloration would hardly be expected.

Relationship of incidental iron addition and detinning. Table 2 discloses a trend toward increasing iron contents of cut-out brine after storage at 70°F.

Table 1. Effect of soaking versus spraying on pH of fresh asparagus during raw product holding, after blanching, and after canning.

Treatment	Initial pH		pH[a]									
			At 18 hr		At 24 hr[b]		At 48 hr[b]			At 72 hr[b]		
	Raw product	Canned no soak	Raw	Canned	Raw	Canned	Raw	Blanched	Canned	Raw	Blanched	Canned
Water soak	6.3	5.5	6.7	5.8	6.7	5.7	6.4	6.7	5.7	6.6	7.0	5.8
Water spray	6.3	5.5	6.4	5.5	6.6	5.4	6.2	6.5	5.5	6.2	6.4	5.5

[a] Values represent average of 2–5 samples.
[b] Times shown designate soak or spray time for treatment of raw product.

Table 2. Effect of iron content of raw product soak water on discoloration of canned all-green asparagus stored at 70°F.[a]

Iron added to soak water[b]	Iron in raw asparagus after soaking	1-week storage		3-month storage		6-month storage	
		Discoloration rating	Iron in brine	Discoloration rating	Iron in brine	Discoloration rating	Iron in brine
(ppm)	*(ppm)*		*(ppm)*		*(ppm)*		*(ppm)*
0	6.7	Slight	5.7	Moderate	22.5	Moderate	22.4
20	7.9	Slight	5.3	Slight	19.3	Bad	32.0
50	9.1	Moderate	5.3	Bad	18.7	Moderate	18.0
100	11.7	Bad	10.7	Moderate	18.7	Bad	38.4

[a] Raw product averaged 49.9 mg rutin per 100-g sample, with a range of 47.6–55.9 mg for 8 random samples. The hot-water-blanched product averaged 44.8 mg per 100 g, with a range of 41.6–47.8 mg per 100 g for 4 random samples.
[b] Soaking consisted of 12-hour immersion for all variables. Ferric ammonium alum was added sufficient to give 20, 50, and 100 ppm iron in the water.

Although the effect of increasing iron content was not brought out clearly by these data, Fig. 3 illustrates the inhibiting effect on detinning caused by iron addition to asparagus. Basically, the lower numerical anodic potential of the tin surface indicates passivation or less sacrificial action of the tinplate surface in the asparagus cut-out brine when iron had been added to the soak water before the asparagus was canned.

Tin content of the cut-out brine from canned asparagus was also suspected to be an important factor in asparagus discoloration. Fig. 4 shows the relationship of the tin-iron ratio of the cut-out brine $\left[\frac{\text{ppm tin in cut-out brine}}{\text{ppm iron in cut-out brine}}\right]$ to asparagus discoloration. The test pack from which these data were obtained was made during the 1955 season at the beginning of our studies to determine possible causes of and corrective measures for asparagus discoloration.

These data show that when the tin-iron ratio of asparagus cut-out brine falls appreciably below 15, discoloration is apt to occur. As the tin-iron ratio asymptotically approaches zero, the degree of discoloration increases. In other words, with extremely low tin content and extremely high iron content, discoloration is likely.

The effectiveness of tin in preventing discoloration is believed due to the presence of tin as the stannous ion in the brine (Cheftel *et al.*, 1955). Examination of standard oxidation potentials indicate that reduction of ferric ion by stannous ion is thermodynamically possible according to the reaction:

$$Sn^{++} + 2\ Fe^{+++} \rightleftarrows 2\ Fe^{++} + Sn^{++++}$$

It is postulated that the ferric ion is reduced to and held in the ferrous state by the stannous ion, preventing product and brine discoloration by diminishing the availability of ferric ion (Fe^{+++}) to combine with rutin. From Fig. 4 and the reaction above, it can be seen that an excess of stannous ions about 15 times as great as the ferrous ions is desirable to prevent discoloration of asparagus. The only exceptions to this relationship of the tin-iron ratio were observed in packed samples to which 0.1% citric acid had been added to the can contents. Thus,

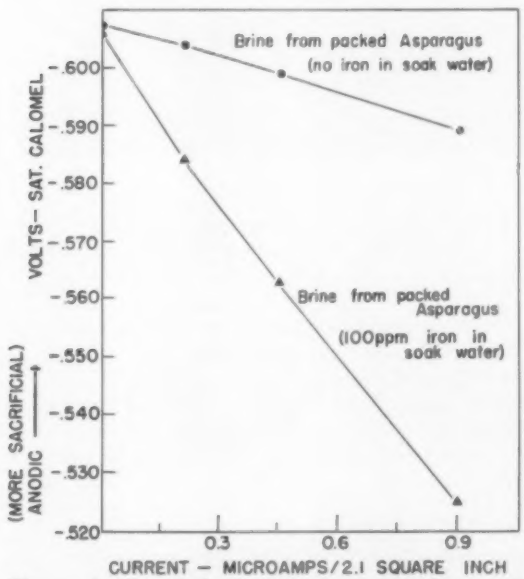

Fig. 3. Anodic polarization curves showing effect on the sacrificial action of 1.25 # hot-dipped tinplate surfaces exposed to asparagus brines.

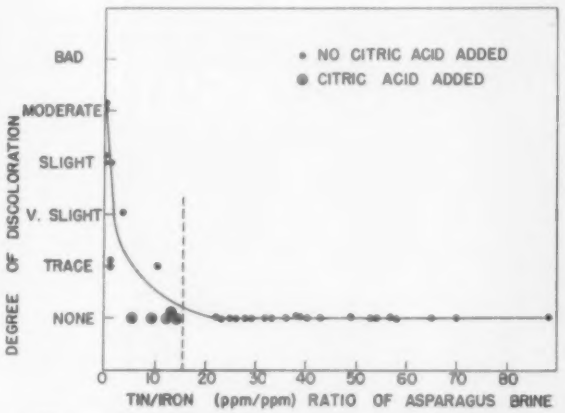

Fig. 4. Tin-iron ratio (ppm) of cut-out asparagus brine after 0, 3, and 6 months at 70 and 100°F.

citric acid appeared to offer promise of control of rutin discoloration.

Citric acid control of discoloration. As early as 1948, Cruess (1948) stated that Wiegand of Oregon Agricultural College had reported that a small amount of acid added to canning brine greatly minimized darkening in canned asparagus. No information was given on the necessary amount or the effect on container shelf life. Tests were therefore designed to answer these and related questions.

Table 3 gives data obtained on companion lots of canned asparagus. Various iron additions to soak water produced discoloration when only a salt brine had been used for canning. When these same lots were packed in salt brine containing added citric acid, however, no discoloration was evident after 12 months.

These data show the effectiveness of 0.10% citric acid-sodium citrate addition in preventing asparagus discoloration in the presence of added iron. The added iron conditions are believed to represent extremes, however, since iron contents of this magnitude would not usually be encountered commercially. Therefore, a companion pack was made with no added iron present and without soaking the raw product before canning so as to compare the effects of citric acid addition at the .025, .050, and 0.10% levels with absence of added citric acid. The results (Table 4) indicate the suitability of .05% citric acid concentration in the contents to prevent asparagus discoloration.

Although similar levels of citric acid were not

Table 3. Effect of citric acid-sodium citrate addition[a] to canning brine on discoloration of canned all-green asparagus stored 12 months at 70°F.

Iron added to soak water[b]	Iron in raw asparagus after soaking	Discoloration rating	
		Brine only	Citric acid–brine
(ppm)	*(ppm)*		
0	6.7	Moderate	None
20	7.9	Moderate	None
50	9.1	Moderate	None
100	11.7	Bad	None

[a] 84.8 g citric acid, 29.0 g sodium citrate added to 10 gal. of brine. Six oz of brine and 10 oz of blanched asparagus were added to each can. 0.10% citric acid-sodium citrate concentration is based on total contents of 303 x 406 container.

[b] Soaking consisted of 12-hour immersion for all variables. Ferric ammonium alum was added sufficient to give 20, 50, and 100 ppm iron in the soak water.

added to canned asparagus having relatively high iron contents, there is a good indication of adequate discoloration control where incidental iron additions are kept at relatively low levels.

Since the actual level of citric acid required to control discoloration was unknown, the 0.10% level was included in the citric acid addition treatments. However, since it had previously been observed that more than 0.05% citric acid addition resulted in a detectable acid flavor (Continental Can Co.), part of the citric acid was replaced with sodium citrate (approximately 25% by weight of citrate ion) to reduce the more acid flavor of the 0.10% citric acid addition level while maintaining the same citrate ion level.

Functions of citric acid in controlling discoloration. Control of discoloration by citric acid addition is believed due to two separate functions of the added citric acid: 1) sequestering effect and 2) pH control.

The sequestering effect of citric acid on ferrous ion in brine has been shown by Bell and Shaw (1958) and McCallion *et al.* (1959). They found citric acid to be an extremely effective sequestrant for iron, even in the presence of high quantities of calcium. Therefore, citric acid is believed to combine with or sequester ferrous ion present in canned asparagus to either retard or prevent oxidation to the ferric ion. Since available ferric ion is necessary to the ferric-rutinate discoloration reaction, ferrous ion sequestered by citric acid is withheld from the discoloration reaction.

Table 4. Effect of various levels of citric acid addition on discoloration of canned all-green asparagus stored at 70°F.

Citric acid concentration of can contents	Discoloration rating at:		
	1 week	3 months	6 months
(%)			
None	Very slight	None	Bad
0.025[a]	Very slight	None	Very slight
0.050[a]	None	None	None
0.10[a]	None	None	None
0.10[b]	None	None	None

[a] Each 303 x 406 can was filled with 6 oz of brine and 10 oz of asparagus. Ten gal. of 2½% salt brine were made up for each variable: 25 g of citric acid were added to obtain 0.025% citric acid concentration based on total can contents; 50 g to obtain 0.050%, and 100 g to obtain 0.10%.

[b] For the product containing 0.10% citric acid-sodium citrate, 84.8 g citric acid and 29.0 sodium citrate were added to 10 gal. of 2½% salt brine.

The importance of pH to the discoloration reaction may be further demonstrated by adding organic or mineral acids to discolored asparagus to reverse the discoloration mechanism, although the reversal reaction rate is quite slow. If, however, the contents of a can of discoloration-prone asparagus are divided into two parts and acid is added to only one part, the discoloration reaction will be prevented when acid is added. Both pH control and the sequestering effect of citric acid have practical application, since discoloration-prone packs of asparagus have been utilized by adding the juice from one lemon to the contents of a #10 can immediately after opening to avert discoloration.

Container shelf life with citric acid additions. Shelf-life data (Table 5) show no large differences in expected container shelf life directly attributable to the various levels of citric acid addition, as measured by hydrogen springer development. These data are further supported by vacuum-loss data for 603 × 700 cans (Fig. 5). Vacuum loss, as determined by the end flip test (Skibbe, 1955), also indicates little difference between the various citric acid treatments as they affect internal corrosion of the containers. The hydrogen gas produced from corrosion reactions causes a gradual decrease in internal vacuum or, conversely, an increase in vacuum loss from the original flip vacuum immediately after packing. Vacuum loss for the 303 × 406 size followed a similar relationship.

Therefore, addition of up to .10% citric acid to the can contents (concentration based on total can content) of all-green asparagus will have no appreciable effect on storage life of the canned processed product when good canning practices are followed. Filling practices and brine addition should be controlled to ensure maintenance of 10 in. or more internal container vacuum as measured by standard puncture vacuum gauges. Maintaining internal can vacuum readings over 10 in. will ensure good com-

Table 5. Effect of citric acid addition on shelf life of canned all-green asparagus after 26 months of storage at 70 and 100°F.

	Months with no springers (70°F)	First springers		Latest springers		Months with no springers (100°F)	First springers		Latest springers	
		Mo.	%	Mo.	%		Mo.	%	Mo.	%
303 x 406										
Control	26	....	....	....	....	16	19	11	22	22
.025[a]	26	....	....	....	....	11	13	14	22	42
.050[a]	26	....	....	....	....	11	19	12	22	12
.10[a]	26	....	....	....	....	19	22	14	22	14
.10[b]	26	....	....	....	....	22	....	....	....	....
603 x 700										
Control	23	....	....	....	....	5	8	12	17	63
.025[c]	23	....	....	....	....	5	8	34	17	88+
.050[c]	18	23	3	23	3	5	8	4	17	50

[a] Each 303 x 406 can was filled with 6 oz of brine and 10 oz of asparagus. Ten gal. of 2½% salt brine were made up for each variable: 25 g of citric acid were added to obtain 0.025% citric acid concentration based on total can contents; 50 g to obtain 0.050%, and 100 g to obtain 0.10%.

[b] For the product containing 0.10% citric acid-sodium citrate, 84.8 g citric acid and 29.0 g sodium citrate were added to 10 gal. of 2½% salt brine.

[c] For 603 x 700 cans, two 150-grain salt tablets were added to the control; two 150-grain salt tables having 4% citric acid were added for .025%, and two 150-grain salt tablets having 9% citric acid were added for .050%.

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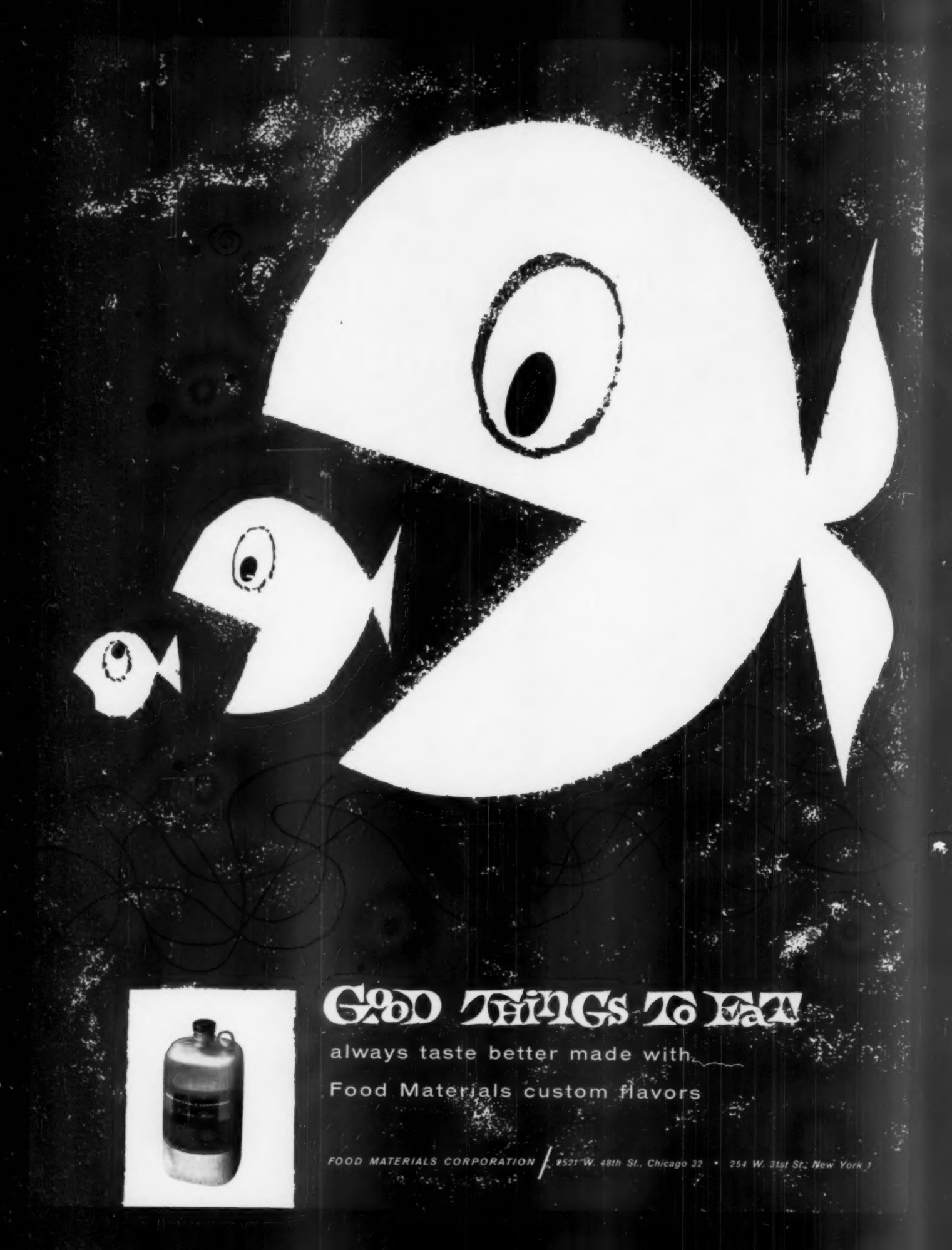
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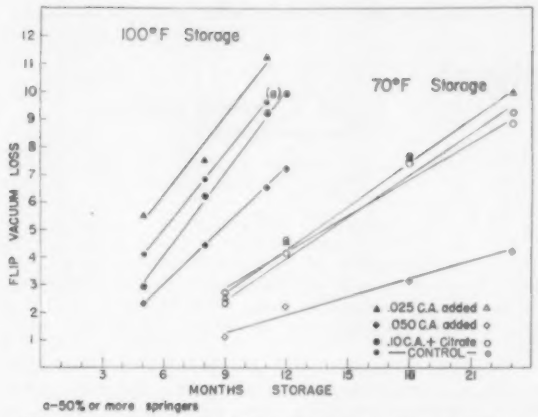

Fig. 5. Vacuum loss during storage at 70 and 100°F of 603 × 700 cans with citric acid additions.

mercial shelf life and good product color, and will also assist in maintaining anodic control of tinplate surfaces, i.e., sacrificial action sufficient to retard iron corrosion from the base steel of the container. Excessive oxygen in the container results in excessive iron dissolution from the container, which may contribute to discoloration as well as to early container failure due to springer formation.

To ensure discoloration in containers smaller than 603 × 700, it was necessary to induce an extremely heavy oxide film on the 303 × 406 containers used. The induced oxide film was equivalent to a natural film that would require 3–5 years to develop under adverse plate or empty-can storage conditions. Use of .05% citric acid also prevented discoloration under these adverse conditions. Therefore, use of empty tin cans stored for extended periods up to one year should offer no discoloration problem with .05% citric acid concentration and good control of other discoloration factors.

CONCLUSIONS

Results presented clearly indicate practical canning procedures for avoiding asparagus discoloration in canned all-green asparagus. Lack of suitable control of these factors may contribute to asparagus discoloration. The main factors to be controlled are:

1. More frequent harvesting of asparagus that shows no evidence of "blossoming" and from shorter stalks will maintain rutin concentration at lower levels, thereby reducing occurrence of severe rutin discoloration.
2. Where product holding is deemed necessary, soaking or water immersion should be limited to a maximum of 24 hours. Low metal exposure of soak tanks is also desirable. Where the cost of stainless-steel tanks is prohibitive, a resin coating may be of value in reducing iron exposure to the lowest practical minimum.
3. Water used for soaking, washing, blanching, and brine make-up should have an original low iron content—less than 2 ppm.
4. Equipment used to convey or store the product, or to handle process waters and canning brines, should preferably be made of stainless steel to maintain incidental iron addition at the lowest practical level.
5. Up to .05% citric acid in the total contents of canned asparagus has been shown to be effective for control of rutin discoloration. This level of citric acid concentration may not control discoloration adequately and consistently in cases where rutin contents are excessive, soaking periods extensive, and/or iron addition excessive, but it is believed to be effective for most existing commercial operations.
6. Up to 0.05% citric acid in the total can contents has no appreciable effect on container shelf life of the canned processed product when the canning practices followed are good.

It is concluded that suitable control of the factors contributing to rutin discoloration of asparagus, and a concentration of up to .05% citric acid based on total can contents, will virtually eliminate oxidative ferric-rutinate discoloration from domestic packs of canned all-green asparagus.

Acknowledgments

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Treatment of Potatoes with Gamma Rays: Effects of Delay Between Harvest and Irradiation[a]

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(Manuscript received August 12, 1960)

SUMMARY

Idaho Russet Burbank potatoes harvested in October were stored at 40°F. Six, 22, and 32 weeks after harvest, separate portions were exposed to 11 kilorads of gamma rays. In June all tubers were transferred to a room at 70–74°F. During the next 8 weeks the controls sprouted extensively, whereas sprouting in the irradiated potatoes was largely, though not completely, suppressed. In contrast to results obtained with onions, the effectiveness of irradiation for sprout control was not affected by delay between harvest and irradiation. Data are presented on total and reducing sugars and on browning tendency.

A NUMBER of investigators have studied the inhibition of sprouting in potatoes by exposure to gamma rays, and the side effects of such treatment (Gustafson *et al.*, 1957; Heiligman, 1957; Schwimmer *et al.*, 1957, 1958; Sparrow and Christensen, 1954; Waggoner, 1955). It is important to know whether irradiation, to be effective, must be done soon after harvest or can be done later. Obviously, cost would be lower if treating facilities could be used during most of the year.

In a previous study here (Schwimmer *et al.*, 1957) potatoes irradiated 5 months after harvest displayed an abrupt increase in sugar content and in browning tendency. The increased sugars largely disappeared in a week or two at 70°F, or more slowly at 40°F. In that experiment, loss of processing quality following irradiation was temporary and reversible.

The present study was designed to show whether delay between harvest and irradiation affects sprout inhibition or the ability of tubers held many months at low temperature to respond to "conditioning" at higher temperatures prior to processing.

MATERIALS AND METHODS

The potatoes used were Russet Burbank grown at the Aberdeen branch of the Idaho Agricultural Experiment Station and harvested October 25, 1955. On receipt at Albany, on November 29, they were placed in a room at 40°F and 85–90% relative humidity. Four randomized samples, each consisting of 80 lb of sound tubers of 4- to 8-oz size, were selected.

Forty-five, 154, and 223 days after harvest a sample was exposed to 11 kilorads of Co^{60} gamma rays at the irradiation facility of Stanford Research Institute, Menlo Park, California. These samples are, respectively, referred to as Series I, II, and III; the fourth sample was an unirradiated control. Samples were transported to and from the Institute in insulated containers previously chilled to 40°, and the total time the samples were out of the 40° room was no more than 5–6 hours.

On the 223rd day after harvest (immediately after irradiation of those delayed 32 weeks) 30 potatoes from each treatment and from the control were withdrawn for determination of total and reducing sugars and of browning tendency; the rest were transferred to 70–74°F for the following 8 weeks. Thirty tubers from each treatment were weighed periodically and examined for sprout growth. After 21 and 35 days of warm conditioning, sugars and browning tendency were again measured.

Total and reducing sugars were determined by Somogyi microcopper method (Somogyi, 1955) before and after hydrolysis; non-sugar-reducing substances were removed by the ion exchange method of Williams *et al.* (1950). Browning tendency was measured by making potato chips and measuring their reflectance by standardized procedures (Harrington *et al.*, 1958). Light-colored chips give high reflectance (L) values; dark chips give low values. Potatoes giving L values below about 45 in this test are unsatisfactory for commercial chip production.

RESULTS AND CONCLUSIONS

Weight loss by respiration and transpiration during 5 weeks' conditioning at 70–74°F was substantially less in the irradiated samples than in the control (Table 1). Measurements after 3 and 8 weeks' conditioning showed the same effect. Suppression of sprouting was nearly complete in the irradiated tubers. There were several sprouts ½ to 2 in. long in each lot, but most sprouts did not exceed ⅛ in., and there was no trend with time elapsed before irradiation. As noted by Schwimmer *et al.* (1957), irradiation did not prevent sprouting, but it did suppress sprout growth at the great majority of eyes. Sprout growth was equally well suppressed in Series III (irradiated 32 weeks after harvest), where the tubers had sprouts about 1/32 in. long before irradiation, and in those held 6½ and 22 weeks, which had been irradiated before visible sprouts appeared. The earlier workers found that apical dominance was suppressed in tubers given too small a dose of irradiation (5.2 kilorads) to prevent sprout growth. In the controls of the present study, a few eyes not primarily those at the apex were dominant, whereas in the irradiated tubers some sprouting or slight sprout elongation occurred at nearly all the eyes.

Table 2 shows the sugar levels in the 4 lots of tubers when taken directly from 40°, and after 3 and 5 weeks' conditioning. At the first sampling the total and reducing sugars were slightly higher in Series II (and

Table 1. Weight loss and sprouting of irradiated potatoes and controls during conditioning.[a]

Post-harvest delay before irradiation	Weight loss (respiration and transpiration) (%)	Weight of sprouts (%)	Length of sprouts (in.)
Control	5.3	6.9	2–8
Series I (6½ wks)	1.9	0.1	1/32–⅛
Series II (22 wks)	3.0	0.3	1/32–⅛
Series III (32 wks)	2.1	0.1	1/32–¼

[a] Conditioned 5 weeks at 70–74°F after 32 weeks at 40°F.

[a] Presented at the 19th Annual Meeting of the Institute of Food Technologists, Philadelphia, Pa., May 17–21, 1959.

[b] A laboratory of the Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

Table 2. Response of irradiated potatoes and controls to conditioning: Sugar content percentages.[a]

Series [b]	Time at 70–74° F					
	0 days		21 days		35 days	
	Total	Reducing	Total	Reducing	Total	Reducing
Control	0.80	0.54	0.34	0.13	0.36	0.14
Series I	1.05	0.65	0.38	0.15	0.32	0.14
Series II	1.12	0.81	0.26	0.09	0.32	0.11
Series III			0.36	0.17	0.46	0.18

[a] Measurements made on potatoes held at 70–74°F after 32 weeks at 40°F.

[b] Control, not irradiated. Series I, II, III, respectively, irradiated 6½, 22, and 32 weeks after harvest.

perhaps in Series I) than in the controls. If these differences are significant, it is possible that the effects of the greatly increased sugar production immediately after irradiation had not been entirely dissipated. After 3 and 5 weeks' conditioning, the sugar levels in all three irradiated series were down to approximately those of the control sample.

Table 3 includes the results of the tests for browning tendency. As would be expected from the data on reducing sugars, the tubers of Series I and II responded to conditioning as well as the control. Chips made from Series III potatoes were slightly darker. All four samples were at or somewhat below the minimum level of acceptability for chip manufacture, but this would be expected after 7½ months at low temperature. After very prolonged storage, potatoes often fail to condition satisfactorily.

From the standpoint of sprout control there appears to be no reason to prefer irradiating potatoes either soon after harvest or after several months' storage at low temperature. This is in sharp contrast to results

Table 3. Response of irradiated potatoes and controls to conditioning: Browning tendency.[a]

Series [b]	Time at 70–74° F		
	0 days	21 days	35 days
Control	29.9	47.7	46.6
Series I	27.5	47.8	45.9
Series II	25.7	46.9	46.1
Series III	.....	41.2	42.9

[a] Reflectance (L) values of potato chips (Harrington *et al.*, 1958) made from tubers held at 70–74°F after 32 weeks at 40°F. Potatoes acceptable for processing give values not lower than about 45.

[b] Control, not irradiated. Series I, II, III, respectively, irradiated 6½, 22, and 32 weeks after harvest.

obtained with onions, where sprouting was effectively suppressed only if the bulbs were irradiated within a short time of harvest (Mullins and Burr, 1961). Potatoes irradiated after prolonged cold storage and immediately before conditioning may not respond quite so well to the higher temperature in terms of processing quality. Because irradiation retards the healing of wounds under some conditions (Waggoner, 1955), gamma-ray treatment at the time the tubers are removed from the cellar or warehouse might be preferable to irradiation immediately after harvest. This would be true only if the potatoes had not already sprouted and if they were to be held at about room temperature for a few weeks before use.

Acknowledgment

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High-Velocity Electron Irradiation of Tomato Paste

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(Manuscript received November 10, 1960)

SUMMARY

The effect of high-velocity electron (HVe) irradiation on ascorbic acid content, color, aroma, and amperometric titration values of tomato paste was investigated. Ascorbic acid retention was 76% at 1×10^6 rads, and 68% at 2×10^6 rads. Under the conditions of this experiment, HVe irradiation caused no significant changes in pH, acidity, or color of the paste. The aroma of the irradiated product became less acceptable as the irradiation dose increased. The sample irradiated at 100,000 rads was slightly inferior in aroma to that of the control sample. The amperometric titration method was used to determine the effect of HVe irradiation on sulfhydryl groups in the constituents of tomato paste. The titratable groups decreased as the irradiation dose increased. The amperometric titration values follow a trend similar to that of the aroma changes caused by HVe irradiation. The effect of irradiation on chemical and quality changes in tomato paste is discussed.

THE DEVELOPMENT of reliable sources of intense high-velocity electrons (HVe), as well as the increased availability of radioactive isotopes, has aroused considerable interest concerning the use of ionizing radiation for food preservation (Bellamy, 1959; Dupaigne, 1958; Ehrenburg, 1954; Goldblith and Proctor, 1955; Hannan, 1955; Schweigert *et al.*, 1955). It is generally agreed that all foods can be sterilized by ionizing radiation. However, many foods subjected to sterilizing doses are altered to some extent in flavor (Groninger *et al.*, 1956; Huber *et al.*, 1953; Morgan, 1955; Pratt and Ecklund, 1956; Proctor, 1959), odor (Batzer and Doty, 1955; Erdman and Watts, 1957), color (Groninger *et al.*, 1956; Schweigert *et al.*, 1955), and vitamins (Groninger *et al.*, 1956; Proctor, 1959; Proctor and O'Meara, 1951).

The purpose of subjecting foods to ionizing radiation is to inactivate the potentially pathogenic and spoiling organisms. It has been applied to only a very limited extent in controlling insect infestations, preventing sprouting of potatoes and onions, and sterilizing pharmaceuticals and medical supplies. Canned foods are still being sterilized by the conventional heating method.

Morgan (1955) reported that the approximate maximum acceptable dose range for tomato juice and concentrate was below 250,000 rep. Recently, Bellamy (1959) stated that odors in irradiated foods may be reduced by the elimination of oxygen during irradiation, by irradiation at frozen temperatures, and by the addition of spices, tomato paste, or antioxidants such as ascorbic acid. Tomato paste was reported very effective. It is presumed that these inhibitors act by one of the following mechanisms: 1) free-radical scavengers such as ascorbic acid; 2) elimination of the indirect effect by freezing the solvent; 3) formation of mercaptals and mercaptols by interaction of mercaptans and carbonyls; 4) interaction of mercaptans with amines; 5) masking undesirable odors with more desirable ones.

The present study presents the effect of HVe irradiation on the ascorbic acid content, color, aroma, and amperometric titration values in tomato paste.

EXPERIMENTAL MATERIALS AND METHODS

Tomato paste. Five hundred pounds of Pearson XL tomatoes inspected by the California State Department of Agriculture were washed, sorted, and trimmed. From the inspection belt, the material passed to a Spike chopper, and was then pumped immediately into a Creamery-Package heat exchanger, where it was heated for 30 seconds at 230°F. The hot macerate went to a pulper with an 0.060-in. screen, and a finisher with a 0.020-in. screen. The pulp was concentrated to a 26% solids paste in a Krenz stainless-steel evaporator under 28 in. of vacuum. The paste was then poured into enameled-meat cans, 6.8 cm in diameter and 2.8 cm in height. The cans were sealed at room temperature in a double seamer, and then irradiated with HVe.

Irradiation with high-velocity electrons. The canned tomato paste was irradiated at various doses in a Mark 1-F 4 electron linear accelerator, supplied by the Applied Radiation Corporation, Walnut Creek, California. Penetration and dose were checked with cobalt chips. The cans were stacked two layers deep on a turntable, and prescribed doses were applied to both sides. The dose rate was 120,000 rad/min, and the pulse was 120 per second. The electron-beam energies were 7.8–8.0 million electron volts (Mev). Unless otherwise stated, the samples were analyzed 24 hours after irradiation.

Ascorbic acid. The 2,6-dichlorophenol-indophenol titration method was used (Association of Vitamin Chemists, 1951). Twenty g of the sample were mixed with 30 ml of water, and then diluted to 100 ml in a volumetric flask with 8% acetic acid. The mixture was filtered through Whatman No. 1 filter paper. Five milliliters of the filtrate was mixed with 50 ml of distilled water and titrated with 0.025% 2,6-dichlorophenol-indophenol dye until the pink color that developed lasted for 15 seconds. The titer was standardized against C.P. ascorbic acid. Results were calculated as mg ascorbic acid per 100 g paste, and then expressed as the percentage retained of the amount originally present in the paste.

Titratable acidity. Duplicate 10-g samples of tomato paste were weighed into 250-ml beakers, and 200 ml of distilled water was added. The resulting mixture was titrated with 0.1*N* sodium hydroxide until the pH reached 8.0 in the Beckman pH meter. The results were expressed as per cent citric acid.

Color. Color of the tomato paste was evaluated in a Gardner automatic color-difference meter (Gardner Laboratory, Inc., Bethesda, Maryland). The unit is similar in design to that of the Hunter difference meter. The reference color plate

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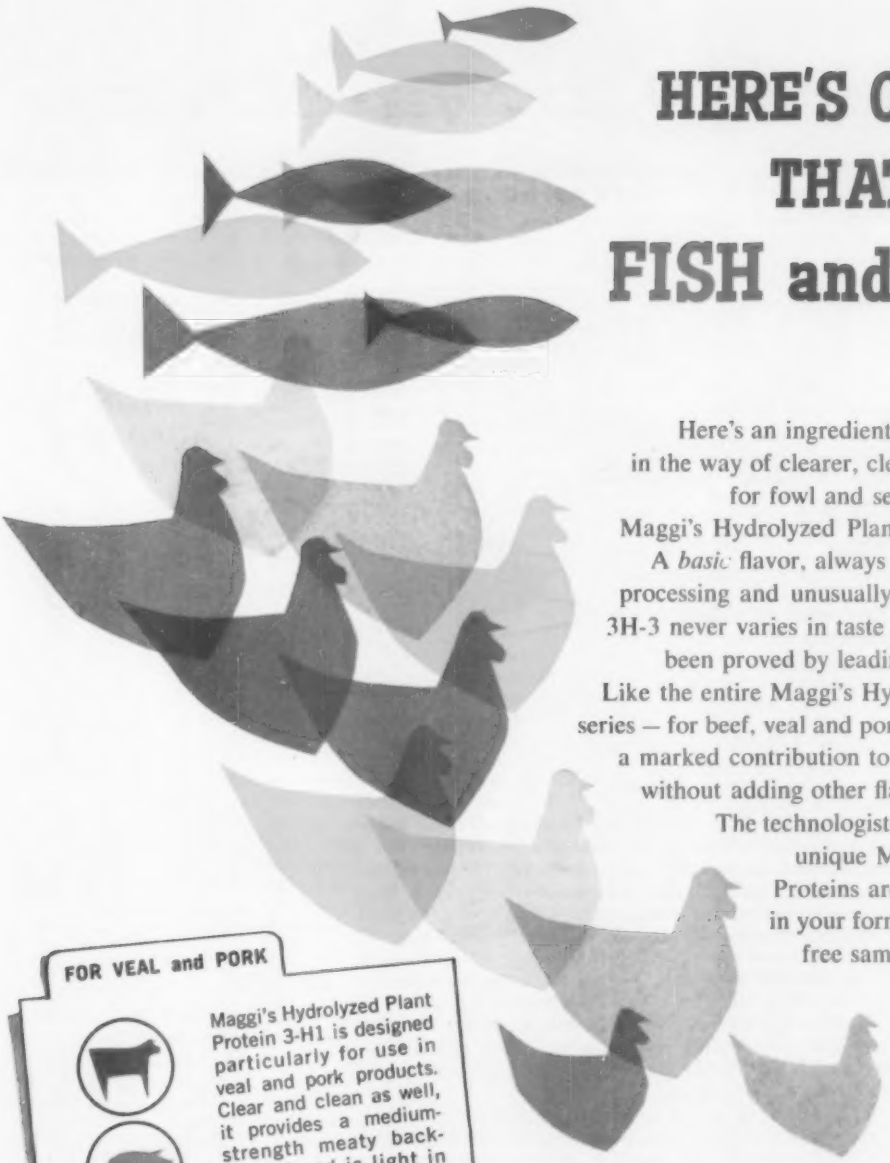

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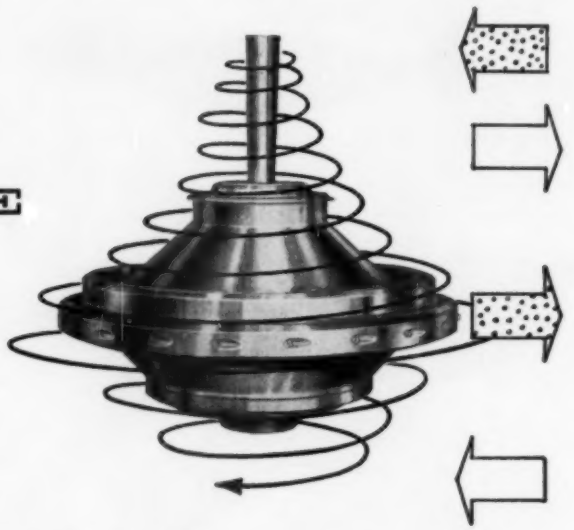

Although the centrifuge has been with us for a long time, its full potentialities are only now being realized in the processing field. Partly, this is due to the increasing demand for faster, more precise methods of separation and classification, adaptable to continuous, automatic operation. More particularly, it is due to radical new developments in the centrifuge itself.

Centrifuges have now become so versatile in operation and have advanced so much in size, power and capability that opportunities for profitable application are virtually unlimited. They are replacing filters, settling tanks, screening and other separation and classification equipment. In many cases, they are cutting days off processing time. Important, too, since the centrifuge substitutes horsepower for size, is the greatly reduced floor space requirements and the smaller amount of critical material needed when handling highly corrosive solutions.

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was a dull-red plate (DRI) with an "Rd" value of 6.0, "a" value of +25.8, and "b" value of +7.5. "Rd" is defined as 100 times the amount of light reflected by a sample, divided by the amount of light reflected by a perfectly diffusing sample (actually, by magnesium oxide). A completely absorbing specimen would have an "Rd" value of zero, and a perfect diffusing white would have a value of 100.

A plus value of "a" indicates redness; and a minus value, greenness. A plus value of "b" indicates yellowness; and a minus value, blueness. The "a" and "b" are thus the rectangular coordinates of color (chromaticity) in any plane intersecting the color solid perpendicularly to the white-black axis.

Aroma. Organoleptic evaluation of the aroma of the irradiated pastes was conducted one day after irradiation by the multiple-comparison method. The 12 judges who participated had extensive experience in evaluating aroma and flavor of processed foods. They scored the aroma of the samples as follows: excellent, 7–8 points; good, 5–6; fair, 3–4; and poor, 1–2. Least-significant differences were determined by the procedure outlined by Adler and Roessler (1958).

Amperometric titration for sulfhydryl groups. The amperometric titration values of the tomato pastes with silver nitrate solution were obtained by slightly modifying the method described by Benesch *et al.* (1955). Ten grams of tomato paste was mixed with distilled water to make 50 ml in a volumetric flask. Ten milliliters of the diluted sample was pipetted, while stirring, into a 100-ml beaker containing 4.0 ml of 1.0*M* tris-hydroxymethylamino methane buffer, 3.4 ml of 1.0*M* nitric acid, and 0.3 ml of 1.0*M* potassium chloride. The pH of the mixture was 7.4. A rotating platinum electrode and the bridge from the reference electrode were immersed in the mixture. This bridge consisted of a short piece of glass tubing fitted with a rolled filter-paper plug (Whatman No. 1) soaked in saturated KCl. The glass tubing was attached to a long piece of Tygon tubing, which led to a 3-way stopcock, which in turn was connected to the reference electrode by a piece of Tygon tubing. The bridge was filled with the filtered electrode solution as far as the 3-way stopcock, and with saturated KCl from the stopcock to the filter-paper plug. The platinum electrode was rotated by a motor. An Evelyn galvanometer was used to measure the current. A 0.0005*M* $AgNO_3$ solution was used as the titrant. Amperometric titrations were carried out in the absence of urea.

RESULTS

Ascorbic acid. Table 1 shows the effect of HVe irradiation on the ascorbic acid content of tomato paste. Ascorbic acid retention at dose levels of 1.0×10^6 and 2.0×10^6 rads was respectively 76% and 68%. As the irradiation dose increased, the ascorbic acid content of the irradiated product decreased.

The irradiated pastes were stored at 98°F and analyzed for ascorbic acid content at five-day intervals to 20 days. No significant decrease in ascorbic acid was found during that period.

The effect of HVe irradiation on the pH and titratable acidity of tomato paste is shown in Table 1. Under the conditions of this experiment, HVe irradiation caused no significant change in pH and titratable acidity of the paste. Thus the changes in ascorbic acid content, aroma, and other properties of irradiated paste cannot be attributed to pH and acidity changes.

Color. The effect of HVe irradiation on the color of tomato paste is shown in Table 1. "Rd" (brightness) was practically unchanged. The "a" values (redness) of the samples subjected to various doses were approximately the same, except in sample F, which was irradiated at a dose of 2.0×10^6 rads, and showed a slightly lower a/b ratio than did the control. The a/b ratio has been used as a criterion of color of tomato products by various research institutes. Well-colored tomato products are usually high in a/b ratio. As the a/b ratios of the irradiated samples did not vary significantly, it is reasonable to conclude that under the conditions of this experiment, the HVe irradiation did not cause significant change in color.

Aroma. The aroma scores of the pastes, evaluated 24 hours after HVe irradiation, are presented in Table 1. As irradiation dose increased, aroma became less acceptable. Sample B, which was irradiated with 0.1×10^6 rads, was slightly inferior in aroma to that of the control sample.

It was reported in the literature that no flavor change was observed in tomato concentrate irradiated with cathode rays at 100,000 rep, but a change was apparent at 250,000 rep (Morgan, 1955). The discrepancy might be attributed to the difference in the type of irradiation equipment and a more sensitive response of the panel to aroma than to flavor changes.

The aroma of the irradiated pastes changed during storage. When stored 20 days at 98°F the samples showed considerable improvement in aroma, although they were still inferior to the heat-sterilized control sample. Some of the off-odor compounds formed by HVe irradiation were probably unstable. They either react with each other or with oxygen in the can during storage. Huber *et al.* (1953) also found that in a variety of canned products, post-irradiation storage was beneficial to reduction or even disappearance of off-flavor.

Amperometric titration. In radiobiochemistry, sulfyhydryl compounds are considered important because of their reactivity with the radicals that result from ionization of water. An extension of this involvement of sulfur groups is the formation of very unpleasant irradiation odors attributed to the rupture of sulfur moieties from the proteins. The last phenomenon has been one of the major deterrents to the use of radiation for preservation of protein foods (Romani and Tappel, 1959).

The amperometric Ag(Tris)+2 titration method was used to determine the effect of HVe irradiation on tomato paste. Fig. 1 shows the titration curves of the diluted paste, which were made according to the method described by Benesch *et al.* (1955). Sample F was irradiated with 2.0×10^6 rads; the volume of 0.0005*N* $AgNO_3$ needed to reach zero galvanometer reading was 2.3 ml. Sample B was irradiated with 0.1×10^6 rads only. The volume of 0.0005*N* $AgNO_3$ needed to reach zero galvanometer reading was 4.3 ml, indicating nearly twice as much reduced sulfhydryls in Sample B as in Sample F.

The effect of HVe irradiation on the amperometric titration value of tomato paste is shown in Fig. 2. As HVe irradiation dose increased, the volume of $AgNO_3$ solution needed to reach zero galvanometric reading decreased. The relationship was not linear. The amperometric titration values seemed to follow a trend similar to the aroma changes caused by HVe irradiation; however, the rates of change of the two factors varied with different doses. A comparison of the aroma data in Table 1 with the amperometric titration values in Fig. 2 indicates that off-odor increased more rapidly in the high dose range, while the amperometric titration values decreased only

Table 1. Effect of high-velocity electron irradiation on ascorbic acid, titratable acidity, color, and aroma of tomato paste.

Sample	Dose (rads)	Ascorbic acid (mg/100 g)	pH	Titratable acid as % citric acid	Gardner color reading				Av. aroma score[a]
					Rd	a	b	a/b	
A	0	57.0	4.22	1.74	5.7	+39.7	+15.3	2.59	7.0
B	0.1×10^6	55.6	4.22	1.75	5.7	+39.3	+15.3	2.57	5.3
C	0.2×10^6	52.6	4.22	1.75	5.7	+39.7	+15.5	2.56	4.5
D	0.5×10^6	46.8	4.20	1.74	5.6	+39.6	+15.4	2.57	3.0
E	1.0×10^6	43.3	4.20	1.74	5.7	+39.6	+15.5	2.56	2.5
F	2.0×10^6	32.8	4.20	1.74	5.6	+39.1	+15.3	2.56	1.3

[a] Higher score represents a better aroma. Least significant difference = 1.5 at 99% probability level.

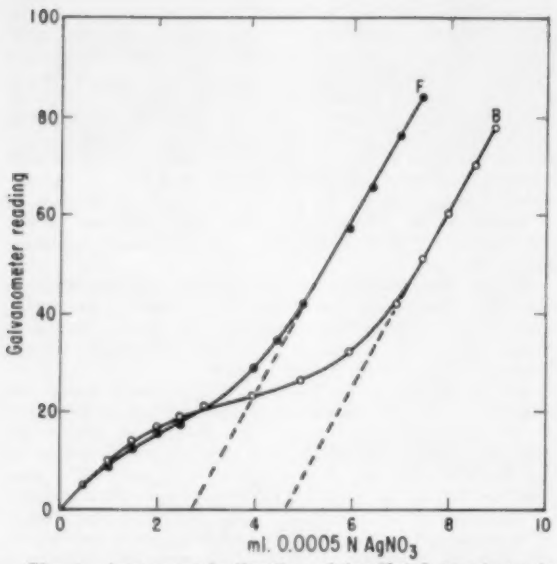

Fig. 1. Amperometric titration of irradiated tomato paste diluted to 6% soluble solids prior to analysis. Sample F, dose $= 2 \times 10^5$ rads; sample B, dose = 100,000 rads.

slightly. This may be explained by the formation of off-odor compounds at high dose levels that are not related to sulfhydryl groups. Similar implications of chemical disruptions prior to complete sulfhydryl oxidation have been noted in the irradiation of pure protein solutions (Romani and Tappel, 1959).

DISCUSSION

Proctor and O'Meara (1951) studied the effect of high-voltage cathode rays on ascorbic acid. They reported that loss of ascorbic acid was smaller in orange juice than in oxalic acid solutions, illustrating the protective effect of substances present with the vitamin in its natural state. Results obtained here seemed to indicate that ascorbic acid was more stable toward HVe irradiation in tomato paste than in oxalic acid solution irradiated with cathode rays.

In the application of ionizing radiation for the preservation of protein foods, the irradiation products responsible for the off-odor have been identified as being principally mercaptans (Bellamy, 1959),

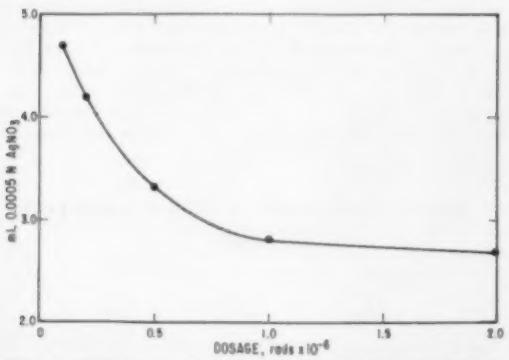

Fig. 2. The effect of high-velocity electron irradiation on the amperometric titration value of tomato paste. The samples were diluted to 6% soluble solids prior to analysis.

hydrogen sulfide, and carbonyl compounds (Duran and Tappel, 1958). Irradiation of methionine produced carbonyls, ammonia, hydrogen sulfide, and mercaptans, which gave undesirable odors. The off-odor in the irradiated tomato paste could come from sulfur-containing amino acids and proteins. Romani and Tappel (1959) demonstrated that molecular disruptions resulting in enzyme inactivation of alcohol dehydrogenase, aldolase, and ribonuclease by irradiation with HVe were closely associated with the formation of characteristic irradiation odors.

The amino acids in tomato juice have been reported (Saravacos *et al.*, 1958). A large portion of the nitrogen was in protein or polypeptide form, as evidenced by the increase in amino acids content after hydrolysis with hydrochloric acid. These proteins probably contributed to the amperometric values for sulfhydryl groups as well as to the off-odors due to irradiation.

The energy of ionization averages about 32 electron volts; this is far in excess of the energy of chemical bonds, which is less than 10 electron volts. It is the chemical action of the ions produced by irradiation that causes the changes in aroma, flavor, and nutritive value of irradiated foods. Unfortunately, the changes brought about by the irradiation dose required for sterilization are damaging to the flavor and nutritive value of foods. Thus, radiation sterilization has not been used by the food processors. Successful application of HVe irradiation for the preservation of tomato paste will not be forthcoming unless the off-odor problem can be solved. A more promising application of radiation may be the use of lower radiation doses for pasteurization and intermediate holding of the food for reprocessing.

In HVe irradiation of foods, the ionizations occurring in the food constituents are called direct effects. And if the energy is absorbed by ionization in the solvent and the ionized or activated solvent molecules react with the solute, it is called an indirect effect. One method of reducing the indirect effect is to immobilize the solvent ions in the food by freezing. Another method for decreasing the efficiency of energy transfer from the water to the food constituents is to add protectors such as cystine, sodium nitrate, glutathione, and others that react with solvent ions more readily than do the protein molecules. Such protectors can be effective against the indirect action but can have little effect on the direct action. Much more is to be learned about the methods for minimizing off-odor formation. The hypothesis that tomato paste may be used as a protector for preventing off-flavor in irradiated foods was not confirmed by HVe irradiation.

Acknowledgments

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Research Notes

Comparison of Kjeldahl, Steam-Distillation, Dye-binding and Formol-Titration Methods for Determining Protein Content of Milk*

In recent years, the solids-not-fat (SNF) constituents of milk have received increased interest mainly because of economical and nutritional factors. Of the individual SNF constituents, the milk proteins have received more attention largely because of their importance in human nutrition. It is therefore not surprising that in recent years several methods have been proposed for routine examination of large numbers of milk samples for protein content. The protein content of milk is usually calculated from the nitrogen content as determined by the Kjeldahl procedure. Kjeldahl analysis of a great number of milk samples, however, is expensive and time-consuming. Various other methods are available, but most promising as routine tests for a great number of milks seem to be the steam-distillation method of Kofranyi and the formol-titration and dye-binding methods. The present paper compares the protein values of mixed herd milks as determined by the steam-distillation, Buffalo Black dye-binding, and formol-titration methods, with Kjeldahl protein values.

EXPERIMENTAL METHODS

Milks. The milks were mixed herd milks from Grade A producers in Brazos County. The samples were stored without preservative under refrigeration (40–45°F). Protein determinations were made within a few days of collection of the samples.

* Journal Paper No. 3608 of the Texas Agricultural Experiment Station, College Station.

Methods. Protein determinations were made according to the following methods: (a) the official macro-Kjeldahl method (Assoc. of Official Agr. Chemists, 1955), (b) a modification of the steam-distillation method of Kofranyi (Vanderzant *et al.*, 1960) (c) a dye-binding method with the disulfonic acid dye Buffalo Black (Vanderzant and Tennison, 1961), and (d) a modification of formol titration as described by Richardson *et al.* (1953).

RESULTS AND DISCUSSION

A comparison of the Kjeldahl protein (% protein) and formol titration values (ml 0.1*N* NaOH) indicated a mean conversion factor of 1.93. This value was slightly higher than the one (1.83) reported by Richardson *et al.* (1953). Table 1 presents an analysis of the protein values of 60 samples of milk as determined by the four methods. The mean protein values were very similar. Highest correlation was between Kjeldahl protein and Buffalo Black protein values, the lowest between Kjeldahl and formol protein values. The correlation of 0.98 between Kjeldahl and Buffalo Black protein values was the same as those reported by Treece *et al.* (1959) and Ashworth *et al.* (1960) for Kjeldahl and Orange G protein values. The differences between individual steam-distillation and Kjeldahl protein values were not greater than 0.1% in 80% of the samples. The same figures for Buffalo Black versus Kjeldahl, and formol-titration versus Kjeldahl protein values were respectively 75 and 65%. In 12% of the samples the differences between individual Kjeldahl and formol-titration protein values were greater than 0.2%. A comparison of the individual Kjeldahl vs steam-distillation, and Kjeldahl vs Buffalo Black protein values, revealed only one sample with a difference of 0.2% protein between methods. A comparison of the duplicate readings (protein values) of the samples by either the steam-distillation or Buffalo Black method showed differences between duplicates of not greater than 0.05% protein in over 90% of the samples. With formol titration, differences between duplicates of greater than 0.05% protein were observed with 37% of the samples. In 7% of the samples these differences were greater than 0.1% protein.

At present the dye-binding test (Orange G or Buffalo Black) seems most promising for routine protein determinations on larger numbers of milk samples. Although each of these routine methods can be used to determine the protein content of milk, certain facts should be kept in mind. The amount of dye bound by the various milk proteins varies (Ashworth and Seals, 1957; Vanderzant and Tennison, 1961). Major changes in the proportions of these proteins in milk may cause important changes in the relationship between Kjeldahl protein and light-absorbance values, which relationship is used in calculating the protein content of milk by the dye-binding method. A similar problem exists with the other two methods. The various milk proteins differ in amide and amino nitrogen content. Hence, the factors relating steam-distillation nitrogen or formol titer to protein content are not constant. However, very little if any difference was found (Vanderzant and Tennison, 1961; Vanderzant *et al.*, 1960) in the value of the conversion factors employed in the dye or steam-distillation method if milks were used from (a) animals of different breeds, (b) mixed herd milks from 20 different farms, (c) animals in late lactation, and (d) animals 5 days after calving.

Addition of arginine, peptones, and calcium chloride to milk affected the accuracy of protein determinations with the Buffalo Black dye-binding method (Schober and Hetzel, 1956). Adulteration of milks with compounds such as urea and ammonium salts would result in too high protein values as determined by the steam-distillation method.

From the viewpoint of handling the samples (methodology), the dye binding method is simple and rapid. The steam-distillation and formol-titration techniques, however, require a great number of manipulations. These detract from their usefulness as field tests unless the techniques can be simplified.

Table 1. Protein values of 60 samples of milk as determined by Kjeldahl, steam-distillation, Buffalo Black dye-binding, and formol-titration methods.

Method	Mean protein value (%)	Correlation	Standard deviation of differences	% of samples deviating from Kjeldahl protein value by more than	
				0.1%	0.2%
Kjeldahl	3.52				
Steam-dist.	3.52	.972[a]	.054	20	1.7
Buffalo Black	3.58	.982[a]	.057	25	1.7
Formol titr.	3.52	.933[a]	.093	35	11.6

[a] Compared with Kjeldahl protein values.

C. Vanderzant and Abdul H. Miah
Texas Agricultural Experiment Station
College Station

November 30, 1960.

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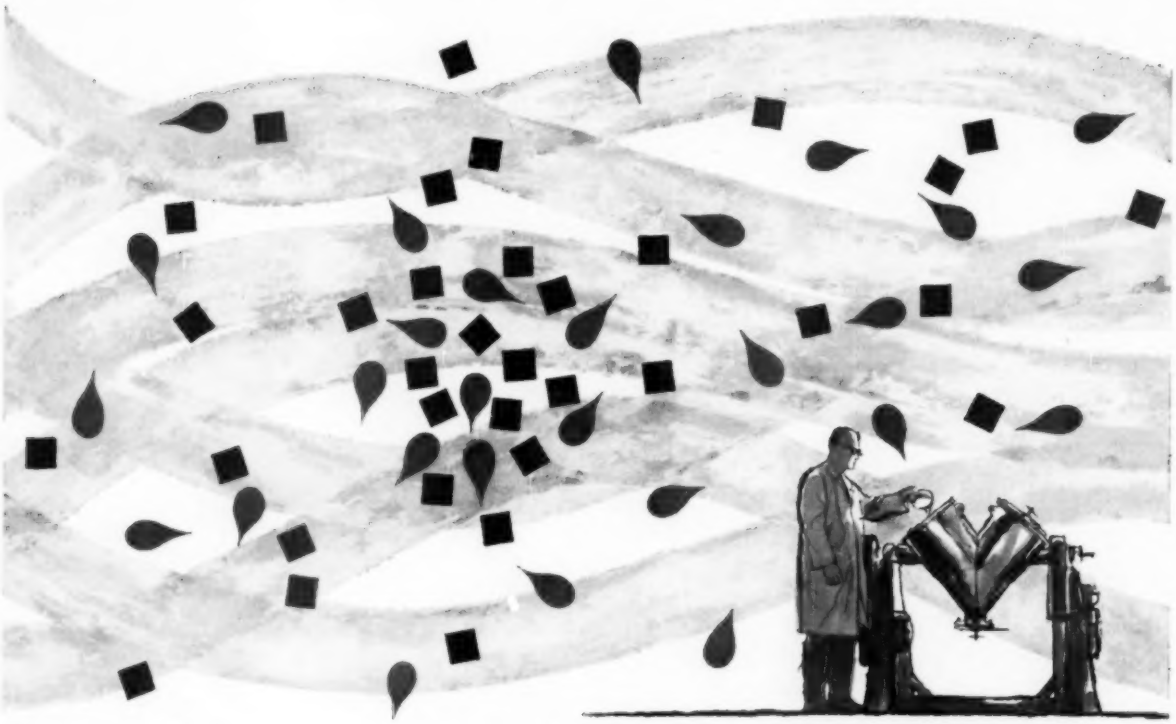

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(Continued from page 20 preceding Technical Section)

Survey results were difficult to define. The number of ideas reportedly coming to the attention of management ranged from 3 to 500 a year. As many as 280 were evaluated, 175 adopted. The average was 140 ideas suggested, 62 evaluated, and 37 adopted.

Some of the conclusions:

Managements apparently accept, but do not actively encourage, new ideas. All companies reporting said they do "not discourage" ideas.

One hundred and fourteen ideas were reviewed with their supposed originators, and 49 persons recommended by management as "good at producing ideas" were interviewed. Half of the 163 said they had attended company meetings called to generate new ideas or solve specific problems.

Many of the "new" ideas (34%) originated with another processor; the "originators" either saw them in operation in, or heard them described by employees of, other processing plants.

Nearly as many ideas (30%) could be classified original; 9% were suggested by suppliers' representatives. The next most important stimulant for new ideas was reported to be reading, yet only 3% of the ideas studied had their direct origin in written material.

S. CALIFORNIA

Dr. Harold W. Schultz, IFT President-Elect, will speak to the Southern California Section Wednesday, April 19th, at a special "booster" meeting. He has chosen the subject: "Where Our Ideas Come From."

H. W. Schultz

In an all-out effort to increase membership, both in the Section and Institute, a Special Booster Committee under the chairmanship of F. Leslie Hart, is contacting as many non-member food technologists in the area as possible, and encouraging attendance.

The method being used is to ask Section Members to contact food technologists within their organization, invite them to the meeting, and give them an "Invitation to Membership" brochure. It is hoped that this effort will increase normal attendance by over one hundred individuals.

This type of activity is heartily encouraged by President Hutchings, who has an objective or "pet project" of attempting to close the gap between IFT membership, and persons potentially qualified for membership. Several years ago it was estimated that there were at least 15,000 persons who could qualify for membership in the United States. Dr. Hutchings welcomes and will give personal attention to ideas which may help achieve this goal.

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The Scientific Advisory Board of Sugar Research Foundation, Inc., met in New York City, February 24, to review the research activities of the Foundation and to counsel it on the 1961–62 program. Members of the Board—recognized leaders in chemistry, nutrition, food technology and government research—gathered for the group photograph, are:

Left to right, seated: Dr. Dale R. Lindsay, Chief, Division of Research Grants, Institutes of Health, **Dr. Emil Mrak,** Chancellor of the University of California at Davis; Dr. Byron T. Shaw, Administrator, Agricultural Research Service, United States Department of Agriculture; **Dr. Louis B. Howard,** Dean of the College of Agriculture, University of Illinois.

Standing: Neil Kelly, Vice President, Sugar Information, Inc.; Ernest W. Greene, President of the Sugar Association, Inc.; **Dr. Charles Glenn King,** Executive Director, The Nutrition Foundation; Robert H. Shields, President of the United States Beet Sugar Association; **Dr. John L. Hickson,** Director of Research, Sugar Research Foundation, Inc.

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Exhibitor Directory

Mr. Hatton B. Rogers of The Nestlé Company, Chairman of the IFT Exhibitors' Advisory Committee, announces that the organizations listed below will exhibit at the 1961 IFT Annual Meeting. The company name, booth number, and products to be displayed, when known, are shown for each of the 120 exhibitors.

Visiting hours for this largest of IFT Industrial Exhibits are: Sunday, May 7—1:00 P.M.–5:00 P.M.; Monday, May 8—11:00 A.M.–4:30 P.M.; Tuesday, May 9—11:00 A.M.–4:30 P.M.; and Wednesday, May 10—11:00 A.M.–4:00 P.M.

Technical personnel will be at booths to answer questions about the products, processes and equipment being shown. Plan now to visit each of the 143 booths during the Annual Meeting, May 7–11 at the Statler Hilton Hotel in New York.

Abbott Laboratories 66

Non-caloric sweetener, Sucaryl, as used in various types of food products

Aerosol Div., Chemical Specialties Manufacturers Association, Inc. 31

Aerosol (pressurized) foods; information center for Aerosol foods

Agtron Company 52

Allied Chemical Corporation, National Aniline Division 79

American Can Company 109 & 110

American Food Laboratories 13

Instant lecithinated stabilizer; instant liquid stabilizer; pure coffee concentrate; pure maple concentrate; true fruit extracts; emulsions and flavors

American Maize-Products Co. 111

Descriptive literature and sample display of corn syrup, corn syrup solids, starches, and lactic acid

American Optical Co. 58

Newly designed stainless steel Hand and Dipping Refractometer with built-in temperature compensator; AO Goldberg Process Refractometer; representative models of Microstar Laboratory and Cycloptic Stereoscopic microscopes; wide variety of other precision optical instruments

American Sterilizer Co. 47 & 48

Freeze drying apparatus for preserving labile chemical and biological material; "Biogen" for continuous culturing of pure microorganisms; water processing equipment; sterilizers and controls

American Viscose Corporation Avicel—a highly purified form of crystalline cellulose shown as a powder, heavy cream and gel.

American Viscose Corporation 5

Avicel crystalline cellulose, a white, free-flowing powder which is a highly purified form of cellulose, for use in foods, drugs and cosmetics

Anderson Bros. Mfg. Co. 133

Model 520 sanitary pump, its construction, and sepia-tone photo blow-ups of other Anderson equipment for food industries

A.P.V. Company, Inc. 11

Scale model of the new APV Plate Evaporator

Archer-Daniels-Midland Co. 139

Proteins for the food industry including Ardex 550, a protein solid specially refined for the food industry

Atlantic Gelatin, Division General Foods Corp. 121

The "ATGEL" brand of gelatin (USP, edible) for food use, and Atlantic Citrus Pectin

Atlas Powder Co. 90

Atlas emulsifiers, sorbitol, and their uses in food processing

Atomic Energy of Canada Limited Gammacell 220, for food preservation experimentation and processing.

Atomic Energy of Canada Limited 129

Gammacell cobalt 60 gamma ir-

Make sure your new ade, juice or instant drink product appeals to nutrition-conscious shoppers by adding Merck Ascorbic Acid. Vitamin C fortification and a positive health claim can help speed your product's acceptance.

Merck is in an excellent position to help you profit from Vitamin C fortification. We are one of the world's largest producers of Ascorbic Acid and deal with food processing problems continually. Our facilities and experience are at your command. Just call in your Merck Representative or write directly to Rahway.

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Please contact us concerning specific allowable levels and details about foods in which these emulsifiers may be used as well as for information about additional emulsifiers which we manufacture for specific food applications.

If you will be at the IFT Meeting in New York May 7th through 11th, please visit us at Booth No. 6. We will be happy to speak with you and answer your inquiries. See you there.

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Polyoxyethylene (20) Sorbitan Mono Stearate
Polyoxyethylene (20) Sorbitan Mono Oleate
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Glyceryl Mono Stearate

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Div. of Chas. L. Huisking & Co. Inc.

417 Fifth Avenue, New York 16, New York

radiation cell; kilocurie cobalt 60 sources for food preservation experimentation and processing; irradiation facilities and consulting services

Bausch & Lomb Inc. 30

Spectronic 20 Colorimeter; spectronic 505 spectrophotometer; dynazoom microscopes

Beatrice Foods Co. 51

New powdered items including Cheddar cheese powders, powdered nut meats (such as peanut butter, walnuts, sesame), flavor foods (such as powdered chocolate and powdered chocolate liquor), easily dispersible diet powders containing unsaturated fats, new starch-fat and vegetable gum fat powders

Blaw-Knox Co., Buflovak Equipment Division 24

Plexiglass motorized model of Buflovak Roto-Vak Agitated Film Evaporator for high capacity heat transfer; laboratory size atmospheric drum dryer, motor operated; bottled sample food products

Brabender Corporation 136

Semi-automatic moisture tester; Farinograph (flour and dough testing machine); Amylograph-viscograph (viscosity testing instrument)

C. W. Brabender Instruments, Inc. 46

Brookfield Engineering Laboratory, Inc. 27

Process instruments for continuously recording and controlling viscosity

Bzura Chemical Co., Inc. 119

Display of samples of Bzura hydrous and anhydrous citric acid

Calgon Company Division —Hagen Chemicals & Controls, Inc. 96

Curafos—cured meat; KENA—poultry; Calgon pea blanching and pectin extractions

Central Soya Co., Inc. 128

Special products from the soybean for the food industry, including isolated soy proteins, protein concentrates, soy flour products and a variety of lecithin products

Centrico, Inc. 140

Photographs, bulletins and descriptive literature showing installations of Centrico centrifugal separators used for clarification of liquids and recovery of valuable solids

Cherry-Burrell Corp. 116 & 117

"Mechanization-Automation" theme. A Round Processor mounted on load cells equipped with an operable instrument panel to demonstrate automatic load-in, load-out and timed agitation. This will show how a complete proportioning system can be handled automatically, as the advantages of instantaneous inventory of bulk products storage

Clinton Corn Processing Co. 14

CLINTOSE brand dextrose, CLINSWEET brand dried corn syrup, Clinton brand lactic acids, corn starches and corn syrups

Continental Can Co., Inc. 87

Coulter Indus. Sales Co. 19

Electronic particle-size distribution analysis equipment

The Creamery Package Mfg. Co. 124 & 125

Actual pumping demonstration showing the CP Rectangular Inlet Positive Rotary Pump continuously moving a very viscous product from a hopper through the pump and back into the hopper; centrifugal pumps and positive pumps; a CP ingredient feeder and product blender will be shown for the first time to an IFT audience

Crest Foods Co., Inc. 8

Concentrated whole proteins of milk for nutritional and functional applications in spray processed and granular forms; lactalbumins

Crown Cork & Seal Co., Inc. 54

The full line of aerosol cans, both seamless and fabricated, and the location of the facilities for manufacture

Diamond Crystal Salt Co. 105

Model "Brinemaster" demonstration; new brochures regarding salt products and applications of interest to several branches of the food industry

Distillation Products Industries 99

Distilled acetylated monoglycerides and related products

Dodge & Olcott, Inc. 85 & 86

Flavors and seasonings for all phases of the food industry: oil-soluble, water soluble, dry soluble, spray-dried; flavors for vitamin compounds, cough syrups, and dental and oral preparations

The Dow Chemical Company 41 & 42

T. M. Duche & Sons, Inc. 25

E. I. du Pont de Nemours & Co., Inc. 81

Durkee Famous Foods 40

Specialty fat, shortening, and oil products for food ingredient use; a complete line of edible emulsifiers and new food oil developments

Eastman Chemical Products, Inc. 100

Analytical methods and procedures for determining the presence and amount of Tenox food-grade antioxidants in food products

Evans Research and Development Corporation 135

F & M Scientific Corp. 126 & 127

The F & M line of linear programmed temperature gas chromatographs featuring flame ionization, hot-wire or thermistor thermal conductivity detection

Felton Chemical Co., Inc. 73

Flavoring materials and their uses

Florasynth Laboratories, Inc. 9 & 10

Introduction of "bacteria-nil" Hy-Dri Sweet Garlic puree and powder; animated display emphasizing Flor-

FOR A PERFECT RECORD OF RETORT PROCESSING

Hang a Cook-Chex tag on every basket before it goes into the retort and eliminate all guess-work when it comes out of the retort. On each Cook-Chex tag, a **chemically impregnated circle** turns from purple to green, to provide infallible proof of proper and complete "in-can" processing. Cannery inspectors approve and recommend Cook-Chex. Major packers all over the world use them to:

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ATI Aseptic-Thermo Indicator Company

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asynth Entrapped and liquid flavors and spices, essential oils, aromas, and cover-odors

Food Machinery & Chemical Corp. 104

FMC continuous cooker, and backdrop photos of freeze-drying equipment and the FMC continuous pressure machine for cooking grain, steam peeling vegetables, countercurrent extraction, etc.

Food Materials Corp. 91

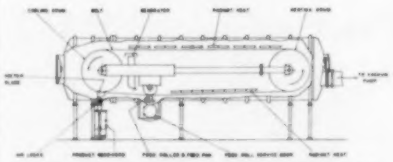
Cake mix flavors, spray-dried flavors, spice extracts, vanillas, fruit flavor concentrates, butterscotch and caramel flavors, and creative product uses for each

Fries & Fries, Inc. 55 & 56

Introduction of newly developed imitation flavors including orange juice, lemon juice, vanilla bean, cooked butter and cheese; beverages made from the first two will be dispensed

Fritzsche Brothers, Inc. 64 & 65

Latest developments in flavors, spice extractions, and spray-dried, locked-in flavors



Girdler Process Equipment VOTATOR Continuous Vacuum Dryer.

Girdler Process Equipment Div.—Chemetron Corp. 1

New Votator Continuous Vacuum Dryer, Votator Scraped Surface Heat Transfer Equipment, and new Votator Rotary Piston and Gravity Fillers

Givaudan Flavors Inc. 80

Self-contained unit featuring Givaudan flavor products

Glyco Chemicals, Division of Chas. L. Huisking & Co., Inc. 6

Emulsifiers for baking, ice cream, candy, and other food applications, including sorbitan fatty acid esters, polyoxyethylene sorbitan fatty acid esters, and glyceryl and propylene glycol fatty acid esters

The Griffith Laboratories, Inc. 97

A moving display, portraying delivery of Griffith's soluble and ground spices, soy proteins, hydrolyzed proteins, to such classes of food plants as meat packers, pickle packers, catsup manufacturers, and bakers

Groen Manufacturing Co. 57

Gunther Products, Inc. 43

Gunther Functional Vegetable Proteins; applicable literature

Charles M. Harrold & Co. 143

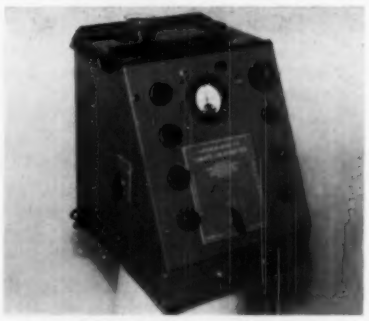
Introduction of two new products, in addition to yeasts, yeast derivatives, protein hydrolysates, supplemental proteins and vitamins that comprise the Harrold Supplemental food and food ingredient line

Hercules Powder Co. 98

Vital wheat gluten; edible wheat starch; gelatized wheat starch; hydrolyzed vegetable proteins, and Hercules cellulose gum

Hoffmann-La Roche Inc. 103

Various forms of Beta Carotene for use as a food color and nutrient; literature on Roche vitamin A and vitamin C



Hunterlab Model D-6 Tomato Colorimeter with glass of tomato juice.

Hunter Associated Laboratories, Inc. 16

Color and color difference meter for color measurement, control and research; techniques for the color measurement of foodstuffs will be demonstrated; D40 Reflectometer

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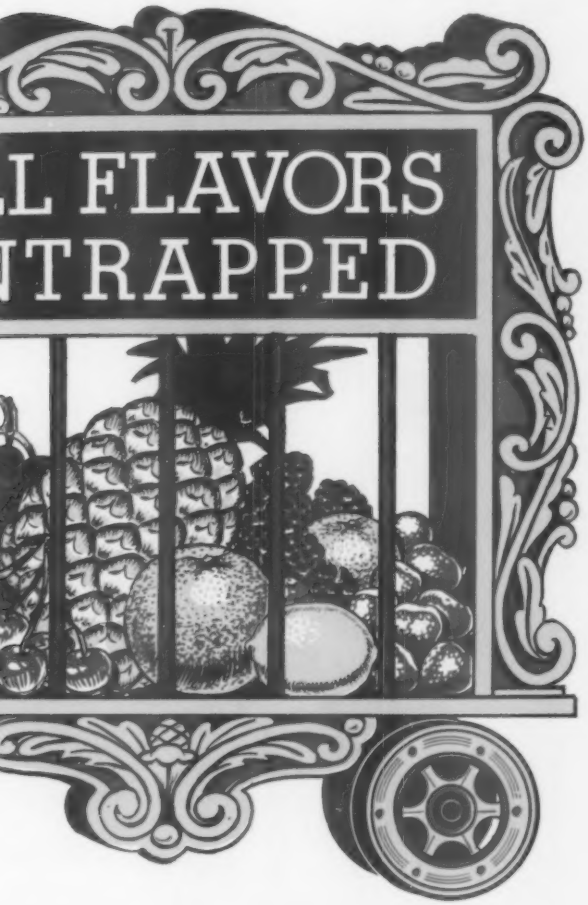

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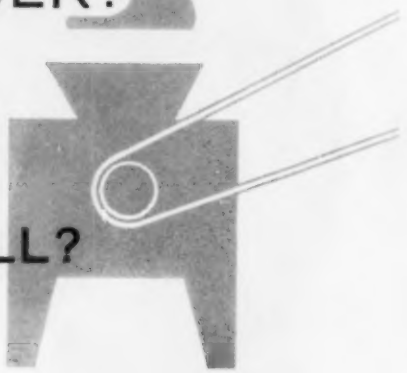
WHAT DO YOU DO TO YOUR PRODUCT?

DO YOU
CRUSH IT
IN A
MEAT GRINDER?

DO YOU
SMASH IT
IN A
HAMMER MILL?



some people don't, you know,

some people cut their product into little dices.

PICKLES for the meat industry are now cut into ¼" or ⅜" cubes.

PICKLE RELISH of high quality is now cut into ⅛" cubes or pieces of ⅛" x ⅛" x ¼".

CHEESE is now being cut into little and big dices. Roquefort cheese is easily diced at a temperature of 10°F.

MEAT with little fibre content such as bologna is cut into small dices for sandwich spreads and other products.

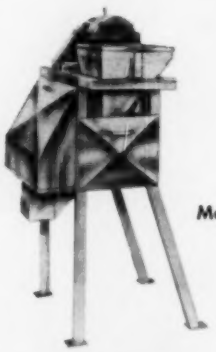
CHERRIES for ice cream dip or other purposes, are cut into little dices.

ALL KINDS OF FRUIT are cut into various small dice sizes for use in numerous products.

NUMEROUS PRODUCTS are now also being cut into julienne strips or thin slices with the "RA".

All of this is accomplished with the Urschel Model "RA" at capacities of up to 10,000 pounds per hour.

We'll be glad to test *your* product in our modern product cutting research kitchen. Write us today.



Model "RA" Dicer

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for grading whiteness and yellowness; D6 tomato colorimeter for grading juice and puree by the USDA formula

International Flavors & Fragrances Inc. 101 & 102

IFF true fruit extracts and other natural flavors, plus imitation flavors, all in liquid, powder and entrapped form; information will be available on flavors for every food use, as well as for pharmaceutical and tobacco use

Kelco Company 71 & 72

Knickerbocker Mills Co. 59

Modern display featuring a world map illustrating the major sources of quality spices and seasonings; sample packages of various Knickerbocker spices and seasonings will be available

H. Kohnstamm & Co., Inc. 94 & 95

Kraft Foods 112 & 113

Ladish Co.—Tri-Clover Division 15

Positive displacement pumps; centrifugal pump that can be cleaned-in-place; air-actuated (automatic) valves, controls and accessories; "Tri-weld" sanitary butt weld fittings and valves; sanitary fittings, valves and specialty items.

Lee-Kramer Shear Press Comptroller for the accurate calibrated measurement of textural rheological properties.

L. E. E. Incorporated 61

An electronic model and mechanical model of the LEE—KRAMER Shear Press Comptroller, with its new fixed maximum dial indicator

Arthur D. Little, Inc. 20 & 21

Depicts Arthur D. Little's worldwide activity in contract research and engineering for the food and other industries

George Lueders & Co., Inc. 4

Macbeth Daylighting Corp. 28

Color-corrected lighting for laboratories, cutting rooms, taste rooms, inspection areas, etc., for raw product grading and processed food grading

Magnus, Mabee & Reynard, Inc. 26

Manton-Gaulin Manufacturing Company, Inc. 74

Demonstration of how Manton-Gaulin homogenizers and colloid mills produce emulsions, dispersions and various products used in the food industry

Marine Colloids, Inc. 12

The Marine Colloids, Inc., line of viscosity producing, milk gelling, water gelling, suspending and stabilizing agents

Marschall Dairy Laboratory, Inc. 18

Display of Annatto Food Colors, Imitation Concentrated Bleu Cheese Flavor; TENDER-MEAT Tenderizers; Rennet Extract & Powders; Lipase Enzyme Preparations; Buttermilk Flavor; Starter Flavor; Anti-Oxidase; Lipolyzed Milk Fat; plus free descriptive literature about these items

Meer Corporation 142

Pictorial review of facilities, services and products; technical literature, catalogues, and product information bulletins for dissemination

Merck & Co., Inc. 82, 83, & 84

Ascorbic acid for fortification of fruit and vegetable juices; Merck MSG for flavor enhancement in foods, and Merck Lysine for upgrading quality of cereal proteins

Miles Chemical Company, Division of Miles Laboratories, Inc. 106

Introduction of Miles new cellulase enzyme; citric acid; erythorbic

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No need to run the risk of contamination from tramp metal. Protect your customers and avoid costly complaints—lawsuits, by finding the things that cause them! Steel, lead, nickel, brass, aluminum—they're all discovered by the RCA Electronic Detector, even pieces as small as .039 in. diameter.

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acid; Miles full line of enzyme products

Mojonnier Bros. Co. 62

Models of the Steam Evaporator and Lo-Temp Evaporator along with various other data and information on the Mojonnier line of equipment for the food processing industry

Monsanto Chemical Co. 7

Animated cafeteria line which demonstrates the variety of foods in which Monsanto's food grade phosphates are used—identifies phosphates, uses, and how phosphates contribute to quality and consumer appeal of products in which they are used

Morningstar-Paisley, Inc. 134

Emphasis on the importance of precise "fluidity-gel" control in enhancing baked goods, confectionery items, dairy products, and frozen, convenience and specialty foods; entire Morningstar-Paisley line of cookup and pregelatinized starches and water-soluble gums for thickening, stabilizing, and emulsifying

Morton Salt Co. 76

A complete review of salt additives, old and new, in relation to Food & Drug Regulations

National Starch and Chemical Corp. 53

The following products will be featured: Col-Flo, Purity 69, Instant Clearjel, and Instant Jel

The Nestlé Co., Inc. 75

Presentation of Maggi's Hydrolyzed Plant Protein products; some of Nestle's bulk chocolate and cocoa items intended for manufacturers' use in the food field

Nopco Chemical Company 37

New food enzymes for the conversion of starches to dextrins (Amylase), for hydrolyzing pectins (Pectinase), for modification of proteins (Proteolytic), and for digestion of cellulose (Cellulase); Nopco vitamins for the fortification of foodstuffs.

Norda Essential Oil & Chemical Co., Inc. 22

A complete essential oil and aromatic flavor exhibit for the food, candy, ice cream and baking trade

Oakite Products, Inc. 49

Oakite RB, a new compound designed for addition to water in retorts and cooling canals, to reduce surface tension of retort and canal water; equipment for mechanized sanitation; compounds for washing produce; compounds for cleaning and sanitizing processing equipment

Henry H. Ottens Mfg. Co., Inc. 141

Shown will be a number of Ottens' more important flavoring materials including special flavor blends, spray-dried powder flavors, vanilla powders, and cultured butter flavors

S. B. Penick & Co. 118

Flavoring specialties including vanilla sugars, vanilla concentrates, extracts, spice oils, oleoresins and water-soluble gums

Penick & Ford, Ltd., Inc. 39

Corn starch derivatives and hydrolyzates arranged in a manner that will demonstrate their broad scope of application in the food industry

Pepsi-Cola Co. 144

"Pepsi-Cola welcomes all convention delegates to enjoy an ice-cold Pepsi at the Company's booth No. 144"

Chas. Pfizer & Co., Inc. 88 & 89

Polak's Frutal Works, Inc. 67

Proctor & Schwartz, Inc. 44

The Quaker Oats Co. 92

New breader mixes, batter mixes and pre-gelatinized flours; samples and technical data on thermo-processed cereals, as well as standard milled items

Radio Corporation of America 50

RePP Industries, Inc. 3

A new line of automatic freeze-drying equipment designed for economical pilot plant testing of proposed food processing applications. The Sublimator 15 will be shown in actual operation

Riegel Paper Corp. 122 & 123
A review of the laboratory facilities and packaging material testing equipment which Riegel employs to tailor packaging materials to specific needs

Rietz Manufacturing Co. 33

F. Ritter & Co. 69

Rohm & Haas Company 93

Schimmel & Co., Inc. 120
Flavoring materials and their applications in the various branches of the food industry

Seeley & Company, Inc. 131
True fruit flavors; spray dried flavors; vanilla flavors; banana flavors; butterscotch flavors; maraschino flavors

Sheffield Chemical, Div. National Dairy Products Corp. 63

Wm. J. Stange Co. 68

Sterwin Chemicals Inc. 108
Sterwin's Vanillin; FD&C food colors; food enrichment tablets; vitamin enrichment powders; and quaternary ammonium germicide

F. J. Stokes Corporation 137 & 138
Emphasis on exhibition of Stokes large-scale freeze-drying production equipment, with some "package" units for laboratory investigation and small-scale production

Sugar Information, Inc. 77 & 78
Distribution of literature

Swift & Company 60
Gelatins for various uses

Ungerer & Company, Inc. 2

Urschel Laboratories, Inc. 29
A display illustrating the sizes and shapes into which food products may be cut on Urschel machinery

The U. S. Stoneware Co. 45

Vacu-Cry Company 32
Dehydrated or low-moisture fruits and vegetables in relation to their application in packaged foods of the convenience type, such as dry cake, salad, cookie, muffin, and other mixes

Vie-Del Grape Products Co. 23
Samples of grape juice concentrate and concentrated wine with alcohol removed.

Virginia Dare Extract Company, Inc. 17
Vanillas: pure, concentrates, imitations, and powders; pure and imitation fruit flavor concentrates; food colors; fruit purees; baker's flavors; specialty and powdered flavors

Wallerstein Company 34
Wallerstein's enzymes and fine chemicals for use in the food industry, and for the assay of food products

Warner-Jenkinson Mfg. Co. 35 & 36
Certified food colors and flavoring extracts

R. D. Webb & Co., Inc. 107
Food flavoring materials emphasizing Webb imitation pineapple and banana flavors

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SARGENT equipment is working wherever there's a drying process in the food industry, from milk curd to poultry stuffing and protein flour. They may be engineered for complete push-button control of the entire drying-cooling operation. They are always designed for your product and your production. May we tell you more?

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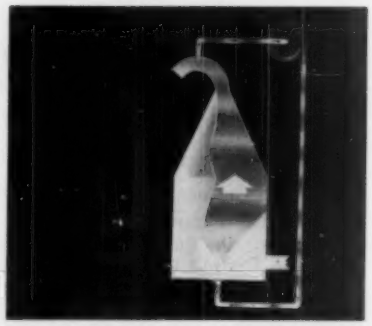
White Cap Company 114 & 115

J. O. Whitten Co., Inc. 130
Gelatin, and new products made from it

Wild Heerbrugg Instruments, Incorporated 132



Use of Wyandotte Vartel, newly developed spray-dried general cleaner.

Wyandotte Chemical Corp. 38
Introduction of Wyandotte Vartel, a newly developed spray-dried general cleaner for use in spray cleaning of storage tanks, spray driers, processing vats and evaporators

Literature

Bulletins

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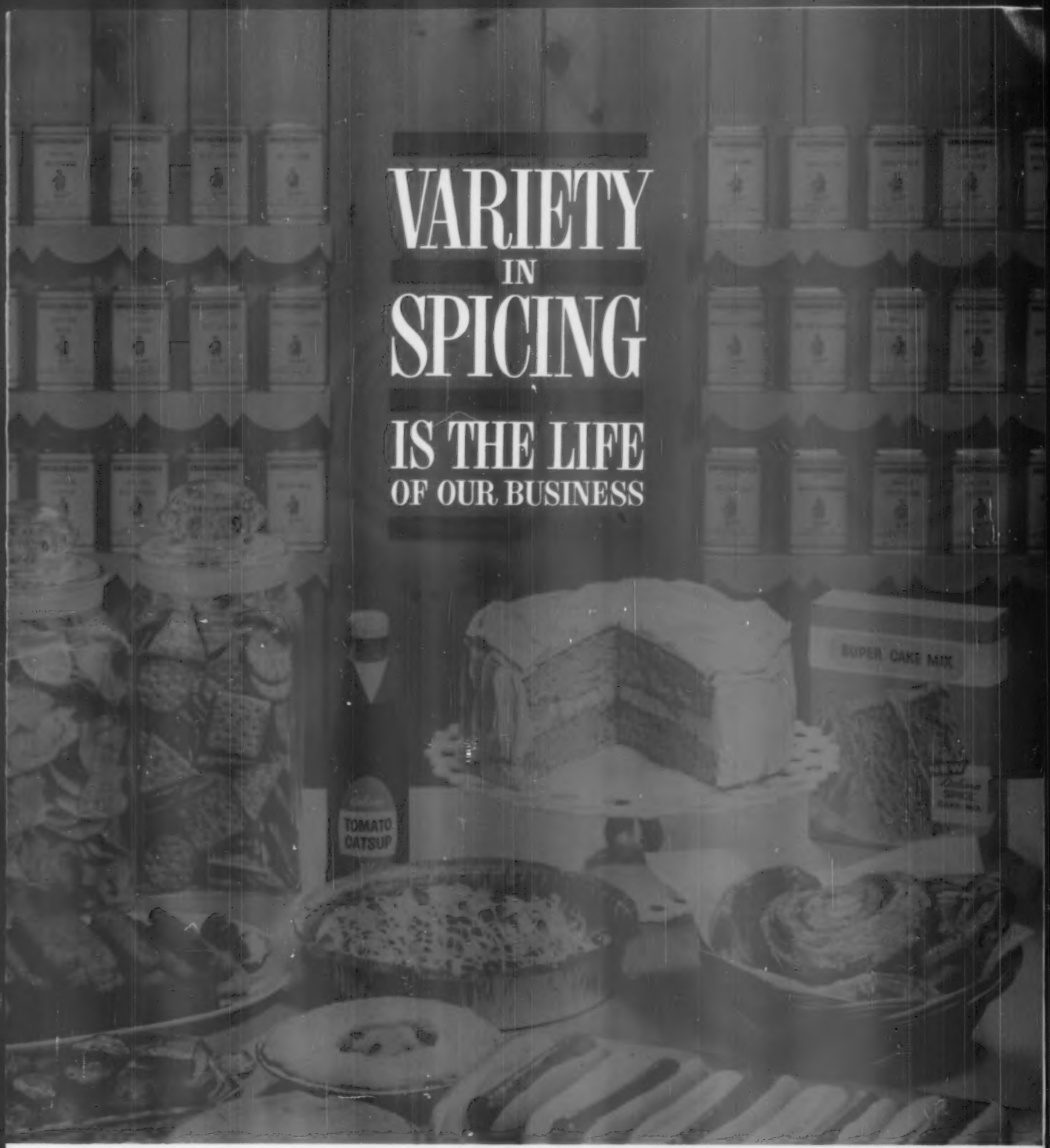

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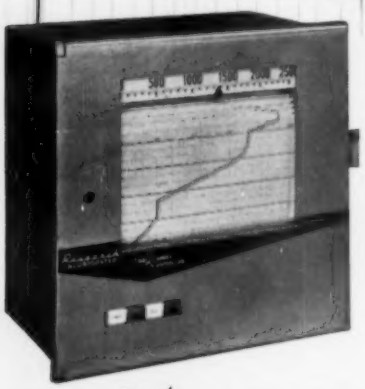

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Write Dept. F, Box 6164, Minneapolis 24, Minn.

1960, California Olive Association, 461 Market Street, San Francisco 5, California.

BOOKS

Marketing Poultry Products, Fifth Edition, 1960, Earl W. Benjamin, James M. Gwin, Fred L. Faber and William D. Termohlen, John Wiley and Sons, Inc., New York, London, $7.75.

* * * *

The Technology of Wine Making, M. A. Amerine and W. V. Cruess, The Avi Publishing Company, Inc., P.O. Box 388, Westport, Conn., $19.00, foreign $20.00.

* * * *

Official Methods of Analysis of the Association of Official Agricultural Chemists, Edited by William Horwitz, Association of Official Agricultural Chemists, P.O. Box 540, Benjamin Franklin Station, Washington 4, D. C., $17.50, foreign postage $0.50 additional.

* * * *

Third Edition Industrial Microbiology, Samuel Cate Prescott and Cecil Gordon Dunn, Revised by Cecil Gordon Dunn, McGraw-Hill Book Company, 330 West 42nd Street, New York 36, N. Y., Toronto, London, $17.50.

* * * *

Physics and Medicine of the Atmosphere and Space, Edited by Otis O. Benson, Jr. and Hubertus Strughold, John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y.

PERSONNEL

In honor of his 25th anniversary with Arthur D. Little, Inc., Loren B. Sjöström was feted by officers and senior employees of the industrial research company at a luncheon. "Johnnie" was presented with a flying acorn service pin by Arthur D. Little, Inc., President James M. Gavin, and an anniversary watch by Raymond Stevens, Chairman of the organization's Executive Committee. That same week he was honored by his fifty immediate associates of the Food and Flavor Section, which he directs, at a surprise luncheon. Mrs. Sjöström attended both celebrations.

L. B. Sjöström

Norman E. Gallagher, New York sales representative of Ungerer & Company, Inc., recently became a member of Ungerer's Quarter-Century Club. At a luncheon held in Mr. Gallagher's honor, Mr. Kenneth G. Voorhees, President of Ungerer & Company, presented him with an engraved gold watch in commemoration of the event.

N. E. Gallagher

Industry News

An amended Food and Drug Administration regulation permits the use of Versene CA as a preservative in sandwich spread, nonstandardized dressings, sauces, oleo-margarine, french dressing, mayonnaise, salad dressing, potato salad, and as an anti-gushing agent in fermented malt beverages, the Dow Chemical Company noted recently. A chelating agent developed specifically for the food industry, Versene CA is used to inactivate trace metals having an adverse effect on color, clarity or stability. Versene CA (calcium disodium ethylenediaminetetraacetate dihydrate, 99% minimum) is prepared as a white, highly purified powder, and is available in commercial quantities or on a sampling basis for laboratory investigation from The Dow Chemical Company, Technical Service and Development Department, Midland, Michigan.

Effective immediately the Society of American Bacteriologists, one of the oldest biological societies in the United States, will be known as the American Society for Microbiology. The new name is considered as more properly descriptive of the broadened scope of the Society's membership and interests. The American Society for Microbiology maintains its headquarters at 19875 Mack Avenue, Detroit 36, Michigan.

Little wonder that today's food processors have a voracious appetite for MSG: Its effectiveness as a flavor enhancer of the widest variety of foods and its improved economies of use create an ever-increasing demand. Merck meets the demand with a 100% increase in MSG production capacity. This $2 million plant expansion puts Merck in the best possible position to supply your MSG needs.

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Reply directly to ad BY BOX NUMBER (where indicated) via: Executive Secretary, Institute of Food Technologists, 176 West Adams Street, Chicago 3, Illinois.

FOOD TECHNOLOGIST with B.S. degree and experience in confectionery, flavor compounding and allied fields, desires responsible position in plant operation or technical sales service. Salary range approximately $12,000 per year. REPLY BOX 852.

Mature Food Technologist, Chemist, having extensive experience in Product Control and Process Development; Plant Operation, Supervision and Management; and Customer/or Technical Service, in area of canning, freezing and pickling desires a responsible position with a parallel food manufacturer or supplier. Location preference in Chicago or near Midwest but would relocate. REPLY BOX 851.

Food Chemist—Technologist, over 15 years experience in vegetables, fruits and other canned foods. Desires position in Quality Control, Product Development or Technical Service. Salary $9,000. REPLY BOX 846.

1950 graduate with ten years experience in Product Development and Quality Control desires position as Food Technologist. Experience in canning and processing has been with fruits and vegetables, dairy, baby foods, pet foods, pilot plant work, and spray drying. Salary $9,500. REPLY BOX 850.

AVAILABLE: Food Technologist, B.S. Purdue 1948. Some graduate work. Experience—canning, carbonated beverages and dairy products. Desire Chicago location. REPLY BOX 849.

Product development or quality control position desired in Chicago area. Individual has ten years experience in quality control covering a wide range of food items including military rations. Salary $8,400. REPLY BOX A-107.

Research food technologist position desired by individual with recent M.S. food technology. Product preference includes meats, vegetables and fruits. Salary, $8,000. REPLY BOX A-311.

Experienced individual with M.S. in dairy mfg. desires line management or manager of product development position. REPLY BOX A-341.

Production or research position in the field of meats desired by recent M.S. graduate. Also interested in flavor and color. Salary, $8,500. REPLY BOX A-324.

Technical service in the dairy and meat industry interests young food technology graduate. Also interested in food inspection. Salary, $6,500. REPLY BOX A-43.

M.S. with experience in dairy, cereals, and beverages desires position similar to director of development and research. Salary, $15–20,000. REPLY BOX A-301.

M.S. in food science desires position as production manager. All experience has been in this area. Salary, $11,000. REPLY BOX A-326.

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WANTED: College graduate, major in Chemistry or Food Technology for work in southeastern pickle plant as head of Quality Control and Assistant Plant Manager. Production background preferred, but pickle experience not required. Established company. Reply should include education, age, experience and present salary. BOX 841.

Product Development Man with degree, and experience in Prepared Cake Mixes. Must be capable of taking charge of all laboratories for well known manufacturer. Reply with résumé to BOX 847.

New York Concern looking for manufacturer of Yogurt Ferment, especially dry type. Write to Carl Tradelius, 124 East 124th Street, New York 35, New York.

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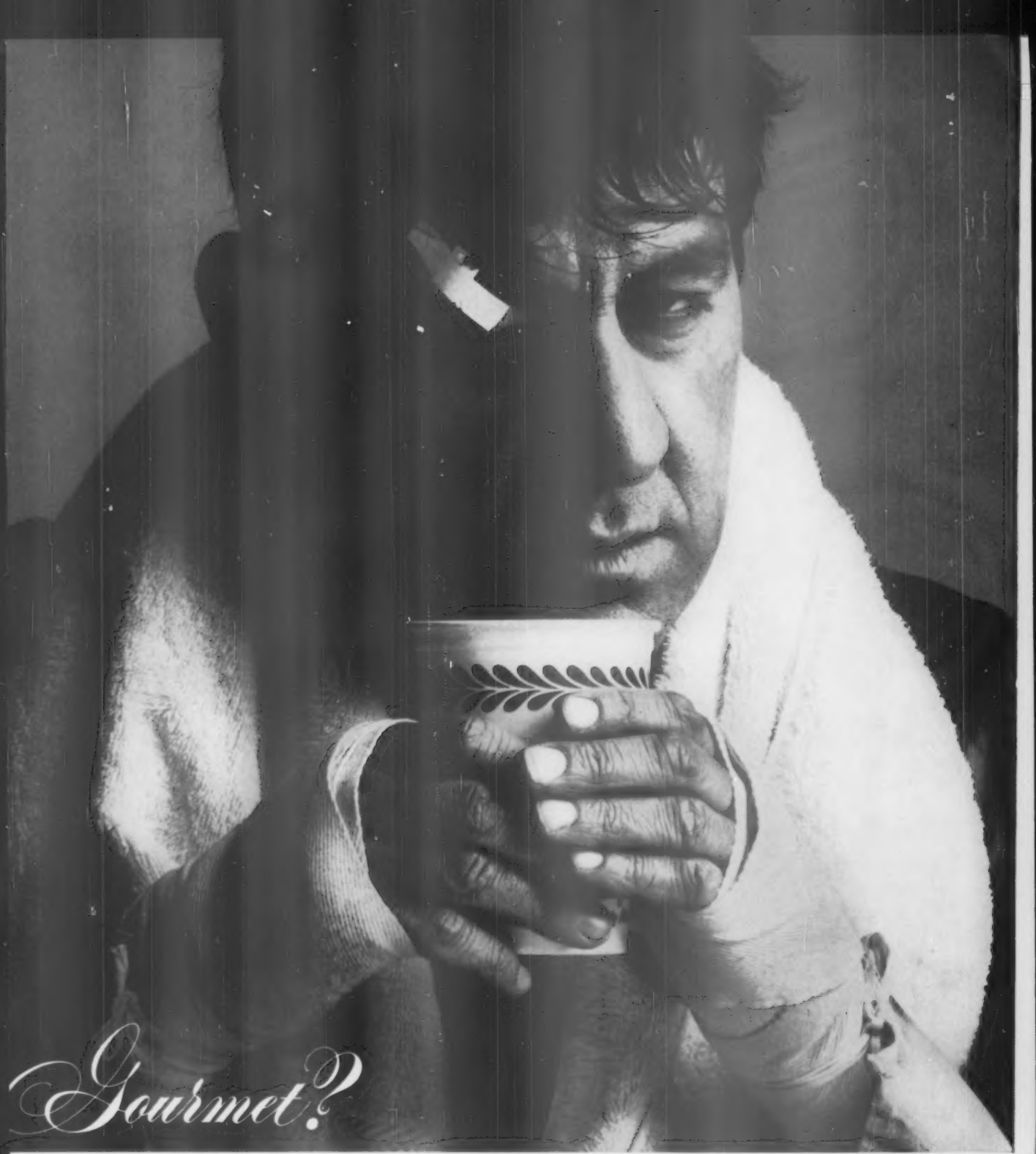

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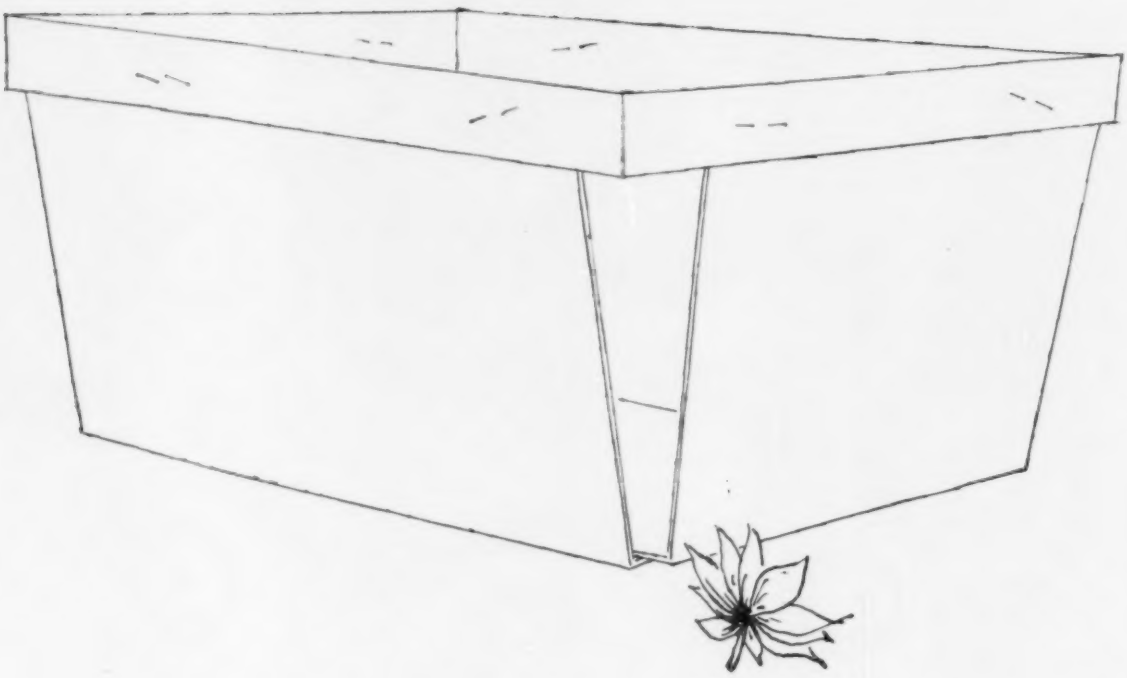

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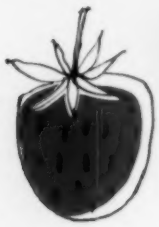

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